INSECT

ARCHITECTURE:

TO WHICH ARE ADDED,

MISCELLANIES,

ON THE RAVAGES,

THE PRESERVATION FOR PURPOSES OF STUDY,

AND

THE CLASSIFICATION, OF INSECTS.

BY

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CHAPTER XIV.

Architecture of Ants.—Mason-Ants.

ALL the species of ants are social. There are none solitary, as is the case with bees and wasps. They are all more or less skilful in architecture; some employing masonry, and others being carpenters, wood-carvers, and miners. They consequently afford much that is interesting to naturalists who observe their operations. The genuine history of ants has only been recently investigated, first by Gould in 1747, and subsequently by Linnæus, De Geer, Huber, and Latreille. Previous to that time their real industry, and their imagined foresight, were held up as moral lessons, without any great accuracy of observation; and it is probable that, even now, the mixture of truth and error in Addison's delightful papers in the Guardian (Nos. 156, 157), may be more generally attractive than the minute relation of careful naturalists. Gould disproved, most satisfactorily, the ancient fable of ants storing up corn for winter provision, no species of ants ever eating grain, or feeding in the winter upon anything. It is to Huber the younger, however, that we are chiefly indebted for our knowledge of the habits and economy of ants; and to Latreille for a closer distinction of the species. Some of the more interesting species, whose singular economy is described by the younger Huber, have not been hitherto found in this country. We shall, however, discover matter of very considerable interest in those which are indigenous;

and as our principal object is to excite inquiry and observation with regard to those insects which may be easily watched in our own gardens and fields, we shall chiefly confine ourselves to the ants of these islands. We shall begin with the labours of those native ants which may be called earth-masons, from their digging in the ground, and forming structures with pellets of moistened loam, clay, or sand.

Mason-Ants.

We have used, in the preceding pages, the terms *mason-bees* and *mason-wasps*, for insects which build their nests of earthy materials. On the same principle, we have followed the ingenious M. Huber the younger, in employing the term mason-ants for those whose nests on the exterior appear to be hillocks of earth, without the admixture of other materials, whilst in the interior they present a series of labyrinths, lodges, vaults, and galleries, constructed with considerable skill. Of these mason-ants, as of the mason wasps and bees already described, there are several species, differing from one another in their skill in the art of architecture.

One of the most common of the ant-masons is the turf-ant (*Formica cæspitum*, Latr.), which is very small, and of a blackish brown colour. Its architecture is not upon quite so extensive a scale as some of the others; but, though slight, it is very ingenious. Sometimes they make choice of the shelter of a flat stone or other covering, beneath which they hollow out chambers and communicating galleries; at other times they are contented with the open ground; but most commonly they select a tuft of grass or other herbage, the stems of which serve for columns to their earthen walls.

We had a small colony of these ants accidentally established in a flower-pot, in which we were rearing some young plants of the tiger-lily (*Lilium tigrinum*), the stems of which being stronger than the grass where they usually build, enabled them to rear their edifice higher, and also to make it more secure, than they otherwise might. It was wholly formed of small grains of moist

earth, piled up between the stems of the lily without any apparent cement; indeed it has been ascertained by Huber, as we shall afterwards see, that they use no cement beside water. This is not always to be procured, as they depend altogether on rains and dew; but they possess the art of joining grains of dry sand so as to support one another, on some similar principle, no doubt, to that of the arch.

The nest which our turf-ants constructed in the flower-pot was externally of an imperfect square form, in consequence of its situation; for they usually prefer a circular plan. The principal chambers were placed under the arches, and, when inspected, contained a pile of cocoons and pupæ. Beneath those upper chambers there were others dug out deeper down, in which were also a numerous collection of eggs and cocoons in various stages of advancement. (J. R.)

Mr. Knapp describes a still more curious structure of another species of ant common in this country:—"One year," says he, "on the third of March, my labourer being employed in cutting up ant-hills, or tumps as we call them, exposed to view multitudes of the yellow species (*Formica flava*) in their winter's retirement. They were collected in numbers in little cells and compartments, communicating with others by means of narrow passages. In many of the cells they had deposited their larvæ, which they were surrounding and attending, but not brooding over or covering. Being disturbed by our rude operations, they removed them from our sight to more hidden compartments. The larvæ were small. Some of these ant-hills contained multitudes of the young of the wood-louse (*Oniscus armadillo*), inhabiting with perfect familiarity the same compartments as the ants, crawling about with great activity with them, and perfectly domesticated with each other. They were small and white; but the constant vibration of their antennæ, and the alacrity of their motions, manifested a healthy vigour. The ants were in a torpid state; but on being removed into a temperate room, they assumed much of their summer's animation. How these creatures are sup-

ported during the winter season it is difficult to comprehend; as in no one instance could we perceive any store or provision made for the supply of their wants. The minute size of the larvæ manifested that they had been recently deposited; and consequently that their parents had not remained during winter in a dormant state, and thus free from the calls of hunger. The preceding month of February, and part of January, had been remarkably severe; the frost had penetrated deep into the earth, and long held it frozen; the ants were in many cases not more than four inches beneath the surface, and must have been enclosed in a mass of frozen soil for a long period; yet they, their young, and the onisci, were perfectly uninjured by it: affording another proof of the fallacy of the commonly received opinion, that cold is *universally* destructive to insect life." *

The earth employed by mason-ants is usually moist clay, either dug from the interior parts of their city, or moistened by rain. The mining-ants and the ash-coloured (*Formica fusca*) employ earth which is probably not selected with so much care, for it forms a much coarser mortar than what we see used in the structure of the yellow ants (*F. flava*) and the brown ants (*F. brunnea*). We have never observed them bringing their building materials of this kind from a distance, like the mason-bees and like the wood or hill ant (*F. rufa*); but they take care, before they fix upon a locality, that it shall produce them all that they require. We are indebted to Huber the younger for the most complete account which has hitherto been given of these operations, of which details we shall make free use.

"To form," says this shrewd observer, "a correct judgment of the interior arrangement or distribution of an ant-hill, it is necessary to select such as have not been accidentally spoiled, or whose form has not been too much altered by local circumstances; a slight attention will then suffice to show that the habitations of the different species are not all constructed after the same

* Journal of a Naturalist, p. 304.

system. This, the hillock raised by the ash-coloured ants will always present thick walls, fabricated with coarse earth, well marked stories, and large chambers, with vaulted ceilings, resting upon a solid base. We never observe roads, or galleries, properly so called, but large passages, of an oval form, and all around considerable cavities and extensive embankments of earth. We further notice, that the little architects observe a certain proportion between the large arched ceilings and the pillars that are to support them.

"The brown ant (*Formica brunnea*), one of the smallest of the ants, is particularly remarkable for the extreme finish of its work. Its body is of a reddish shining brown, its head a little deeper, and the antennæ and feet a little lighter in colour. The abdomen is of an obscure brown, the scale narrow, of a square form, and slightly scolloped. The body is one line and two-fifths in length.*

"This ant, one of the most industrious of its tribe, forms its nest of stories four or five lines in height. The partitions are not more than half a line in thickness; and the substance of which they are composed is so finely grained, that the inner walls present one smooth unbroken surface. These stories are not horizontal; they follow the slope of the ant-hill, and lie one upon another to the ground-floor, which communicates with the subterranean lodges. They are not always, however, arranged with the same regularity, for these ants do not follow an invariable plan; it appears, on the contrary, that nature has allowed them a certain latitude in this respect, and that they can, according to circumstances, modify them to their wish; but, however fantastical their habitations may appear, we always observe they have been formed by concentrical stories. On examining each story separately, we observe a number of cavities or halls, lodges of narrower dimensions, and long galleries, which serve for general communication. The arched ceilings covering the most spacious places are supported either by little co-

* A line is the twelfth part of the old French inch. *See* Companion to the Almanac for 1830, p. 114.

lumns, slender walls, or by regular buttresses. We also notice chambers, that have but one entrance, communicating with the lower story, and large open spaces, serving as a kind of cross-road (*carrefour*), in which all the streets terminate.

"Such is the manner in which the habitations of these ants are constructed. Upon opening them, we commonly find the apartments, as well as the large open spaces, filled with adult ants; and always observed their pupæ collected in the apartments more or less near the surface. This, however, seems regulated by the hour of the day, and the temperature: for in this respect these ants are endowed with great sensibility, and know the degree of heat best adapted for their young. The ant-hill contains, sometimes, more than twenty stories in its upper portion, and at least as many under the surface of the ground. By this arrangement the ants are enabled, with the greatest facility, to regulate the heat. When a too burning sun over-heats their upper apartments, they withdraw their little ones to the bottom of the ant-hill. The ground-floor becoming, in its turn, uninhabitable during the rainy season, the ants of this species transport what most interests them to the higher stories; and it is there we find them more usually assembled, with their eggs and pupæ, when the subterranean apartments are submerged."*

Ants have a great dislike to water, when it exceeds that of a light shower to moisten their building materials. One species, mentioned by Azara as indigenous to South America, instinctively builds a nest from three to six feet high,† to provide against the inundations during the rainy season. Even this, however, does not always save them from submersion; and, when that occurs, they are compelled, in order to prevent themselves from being swept away, to form a group somewhat similar to the curtain of the wax-workers of hive-bees (see vol. i. p. 112). The ants constituting the basis of this group, lay hold of

* M. P. Huber on Ants, p. 20.

† Stedman's Surinam, vol. i., p. 160.

some shrub for security, while their companions hold on by them; and thus the whole colony, forming an animated raft, floats on the surface of the water till the inundation (which seldom continues longer than a day or two) subsides. We confess, however, that we are somewhat sceptical respecting this story, notwithstanding the very high character of the Spanish naturalist.

It is usual with architectural insects to employ some animal secretion, by way of mortar or size, to temper the materials with which they work; but the whole economy of ants is so different, that it would be wrong to infer from analogy a similarity in this respect, though the exquisite polish and extreme delicacy of finish in their structures, lead, naturally, to such a conclusion. M. P. Huber, in order to resolve this question, at first thought of subjecting the materials of the walls to chemical analysis, but wisely (as we think) abandoned it for the surer method of observation. The details which he has given, as the result of his researches, are exceedingly curious and instructive. He began by observing an ant-hill till he could perceive some change in its form.

"The inhabitants," says he, "of that which I selected, kept within during the day, or only went out by subterranean galleries which opened at some feet distance in the meadow. There were, however, two or three small openings on the surface of the nest; but I saw none of the labourers pass out this way, on account of their being too much exposed to the sun, which these insects greatly dread. This ant-hill, which had a round form, rose in the grass, at the border of a path, and had sustained no injury. I soon perceived that the freshness of the air and the dew invited the ants to walk over the surface of their nest; they began making new apertures; several ants might be seen arriving at the same time, thrusting their heads from the entrances, moving about their antennæ, and at length adventuring forth to visit the environs.

"This brought to my recollection a singular opinion of the ancients. They believed that ants were occupied

in their architectural labours during the night, when the moon was at its full." *

M. Latreille discovered a species of ants which were, so far as he could ascertain, completely blind,† and of course it would be immaterial to them whether they worked by night or during the day. All observers indeed agree that ants labour in the night, and a French naturalist is therefore of opinion that they never sleep, —a circumstance which is well ascertained with respect to other animals, such as the shark, which will track a ship in full sail for weeks together.‡ The ingenious historian of English ants, Gould, says they never intermit their labours by night or by day, except when compelled by excessive rains. It is probable the ancients were mistaken in asserting that they only work when the moon shines ;§ for, like bees, they seem to find no difficulty in building in the dark, their subterranean apartments being as well finished as the upper stories of their buildings. But to proceed with the narrative of M. P. Huber.

"Having thus noticed the movements of these insects during the night, I found they were almost always abroad and engaged about the dome of their habitation after sunset. This was directly the reverse of what I had observed in the conduct of the wood-ants (*F. rufa*), who only go out during the day, and close their doors in the evening. The contrast was still more remarkable than I had previously supposed; for upon visiting the brown ants some days after, during a gentle rain, I saw all their architectural talents in full play.

"As soon as the rain commenced, they left in great numbers their subterranean residence, re-entered it almost immediately, and then returned, bearing between

* M. P. Huber on Ants, p. 23.

† Latreille, Hist. Nat. des Fourmis.

‡ Dr. Cleghorn, Thesis de Somno.

§ Aristotle, Hist. Animal. ix. 38. Pliny says, "Operantur et noctu plenâ lunâ; eadem interlunio cessant," *i. e.* They work in the night at full moon, but they leave off between moon and moon. It is the latter that we think doubtful.

their teeth pellets of earth, which they deposited on the roof of their nest. I could not at first conceive what this was meant for, but at length I saw little walls start up on all sides with spaces left between them. In several places, columns, ranged at regular distances, announced halls, lodges, and passages, which the ants proposed establishing; in a word, it was the rough beginning of a new story.

"I watched with a considerable degree of interest the most trifling movements of my masons, and found they did not work after the manner of wasps and humble-bees, when occupied in constructing a covering to their nest. The latter sit, as it were, astride on the border or margin of the covering, and take it between their teeth to model and attenuate it according to their wish. The wax of which it is composed, and the paper which the wasp employs, moistened by some kind of glue, are admirably adapted for this purpose, but the earth of which the ants make use, from its often possessing little tenacity, must be worked up after some other manner.

"Each ant, then, carried between its teeth the pellet of earth it had formed by scraping with the end of its mandibles the bottom of its abode, a circumstance which I have frequently witnessed in open day. This little mass of earth, being composed of particles but just united, could be readily kneaded and moulded as the ants wished; thus, when they had applied it to the spot where they had to rest, they divided and pressed against it with their teeth, so as to fill up the little inequalities of their wall. The antennæ followed all their movements, passing over each particle of earth as soon as it was placed in its proper position. The whole was then rendered more compact by pressing it lightly with the fore-feet. This work went on remarkably fast. After having traced out the plan of their masonry, in laying here and there foundations for the pillars and partitions they were about to erect, they raised them gradually higher, by adding fresh materials. It often happened that two little walls, which were to form a gallery, were raised opposite, and at a

slight distance from each other. When they had attained the height of four or five lines, the ants busied themselves in covering in the space left between them by a vaulted ceiling.

"As if they judged all their partitions of sufficient elevation, they then quitted their labours in the upper part of the building; they affixed to the interior and upper part of each wall fragments of moistened earth, in an almost horizontal direction, and in such a way as to form a ledge, which, by extension, would be made to join that coming from the opposite wall. These ledges were about half a line in thickness; and the breadth of the galleries was, for the most part, about a quarter of an inch. On one side several vertical partitions were seen to form the scaffolding of a lodge, which communicated with several corridors, by apertures formed in the masonry; on another, a regularly-formed hall was constructed, the vaulted ceiling of which was sustained by numerous pillars; further off, again, might be recognised the rudiments of one of those cross roads of which I have before spoken, and in which several avenues terminate. These parts of the ant-hill were the most spacious; the ants, however, did not appear embarrassed in constructing the ceiling to cover them in, although they were often more than two inches in breadth.

"In the upper part of the angles formed by the different walls, they laid the first foundations of this ceiling, and from the top of each pillar, as from so many centres, a layer of earth, horizontal and slightly convex, was carried forward to meet the several portions coming from different points of the large public thoroughfare.

"I sometimes, however, laboured under an apprehension that the building could not possibly resist its own weight, and that such extensive ceilings, sustained only by a few pillars, would fall into ruin from the rain which continually dropped upon them; but I was quickly convinced of their stability, from observing that the earth brought by these insects adhered at all points, on the slightest contact; and that the rain, so far from lessening

the cohesion of its particles, appeared even to increase it. Thus, instead of injuring the building, it even contributed to render it still more secure.

"These particles of moistened earth, which are only held together by juxtaposition, require a fall of rain to cement them more closely, and thus varnish over, as it were, those places where the walls and galleries remain uncovered. All inequalities in the masonry then disappear. The upper part of these stories, formed of several pieces brought together, presents but one single layer of compact earth. They require for their complete consolidation nothing but the heat of the sun. It sometimes, however, happens that a violent rain will destroy the apartments, especially should they be but slightly arched; but under these circumstances the ants reconstruct them with wonderful patience.

"These different labours were carried on at the same time, and were so closely followed up in the different quarters, that the ant-hill received an additional story in the course of seven or eight hours. All the vaulted ceilings being formed upon a regular plan, and at equal distances from one wall to the other, constituted, when finished, but one single roof. Scarcely had the ants finished one story than they began to construct another; but they had not time to finish it—the rain ceasing before the ceiling was fully completed. They still, however, continued their work for a few hours, taking advantage of the humidity of the earth; but a keen north wind soon sprung up, and hastily dried the collected fragments, which, no longer possessing the same adherence, readily fell into powder. The ants, finding their efforts ineffectual, were at length discouraged, and abandoned their employment; but what was my astonishment when I saw them destroy all the apartments that were yet uncovered, scattering here and there over the last story the materials of which they had been composed! These *facts* incontestably prove, that they employ neither gum, nor any kind of cement, to bind together the several substances of their nest; but in place of this avail them

selves of the rain, to work or knead the earth, leaving the sun and wind to dry and consolidate it." *

Dr. Johnson of Bristol observed very similar proceedings in the case of a colony of red ants (*Myrmica rubra?*), the roof of whose nest was formed by a flat stone. During dry weather, a portion of the side walls fell in; but the rubbish was quickly removed, though no repairs were attempted till a shower of rain enabled them to work. As soon as this occurred, they worked with extraordinary rapidity, and in a short time the whole of the fallen parts were rebuilt, and rendered as smooth as if polished with a trowel.

When a gardener wishes to water a plot of ground where he has sown seeds that require nice management, he dips a strong brush into water, and passes his hand backwards and forwards over the hairs for the purpose of producing a fine artificial shower. Huber successfully adopted the same method to excite his ants to recommence their labours, which had been interrupted for want of moisture. But sometimes, when they deem it unadvisable to wait for rain, they dig down (as we remarked to be the practice of the mason-bees) till they arrive at earth sufficiently moist for their purpose. They do not, however, like these bees, merely dig for materials; for they use the excavations for apartments, as well as what they construct with the materials thence derived. They appear, in short, to be no less skilful in mining than in building.

Such is the general outline of the operations of this singular species; but we are still more interested with the history which M. P. Huber has given of the labours of an individual ant. "One rainy day," he says, "I observed a labourer of the dark ash-coloured species (*Formica fusca*) digging the ground near the aperture which gave entrance to the ant-hill. It placed in a heap the several fragments it had scraped up, and formed them into small pellets, which it deposited here and there

* M. P. Huber on Ants, p. 31.

upon the nest. It returned constantly to the same place, and appeared to have a particular design, for it laboured with ardour and perseverance. I remarked a slight furrow, excavated in the ground in a straight line, representing the plan of a path or gallery. The labourer (the whole of whose movements fell under my immediate observation) gave it greater depth and breadth, and cleared out its borders; and I saw, at length—in which I could not be deceived—that it had the intention of establishing an avenue which was to lead from one of the stories to the underground chambers. This path, which was about two or three inches in length, and formed by a single ant, was opened above, and bordered on each side by a buttress of earth. Its concavity, in the form of a pipe (*gouttière*), was of the most perfect regularity; for the architect had not left an atom too much. The work of this ant was so well followed and understood, that I could almost to a certainty guess its next proceeding, and the very fragment it was about to remove. At the side of the opening where this path terminated was a second opening, to which it was necessary to arrive by some road. The same ant began and finished this undertaking without assistance. It furrowed out and opened another path, parallel to the first, leaving between each a little wall of three or four lines in height."

Like the hive-bees, ants do not seem to work in concert, but each individual separately. There is, consequently, an occasional want of coincidence in the walls and arches; but this does not much embarrass them, for a worker, on discovering an error of this kind, seems to know how to rectify it, as appears from the following observations:—

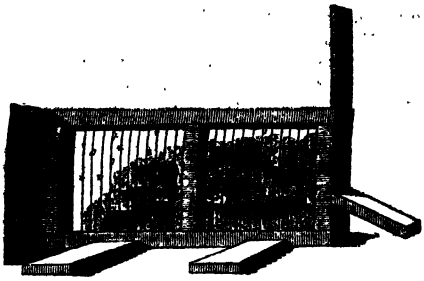
"A wall," says M. Huber, "had been erected, with the view of sustaining a vaulted ceiling, still incomplete, that had been projected towards the wall of the opposite chamber. The workman who began constructing it, had given it too little elevation to meet the opposite partition, upon which it was to rest. Had it been continued on the original plan, it must infallibly have met the wall at about one half of its height; and this it was necessary

to avoid. This state of things very forcibly claimed my attention; when one of the ants arriving at the place, and visiting the works, appeared to be struck by the difficulty which presented itself; but this it as soon obviated, by taking down the ceiling, and raising the wall upon which it reposed. *It then, in my presence, constructed a new ceiling with the fragments of the former one.*

"When the ants commence any undertaking, one would suppose that they worked after some preconceived idea, which, indeed, would seem verified by the execution. Thus, should any ant discover upon the nest two stalks of plants which lie crossways, a disposition favourable to the construction of a lodge, or some little beams that may be useful in forming its angles and sides, it examines the several parts with attention; then distributes, with much sagacity and address, parcels of earth in the spaces, and along the stems, taking from every quarter materials adapted to its object, sometimes not caring to destroy the work that others had commenced; so much are its motions regulated by the idea it has conceived, and upon which it acts, with little attention to all else around it. It goes and returns, until the plan is sufficiently understood by its companions.

"In another part of the same ant-hill," continues M. Huber, "several fragments of straw seemed expressly placed to form the roof of a large house; a workman took advantage of this disposition. These fragments lying horizontally, at half an inch distance from the ground, formed, in crossing each other, an oblong parallelogram. The industrious insect commenced by placing earth in the several angles of this frame-work, and all along the little beams of which it was composed. The same workman afterwards placed several rows of the same materials against each other, when the roof became very distinct. On perceiving the possibility of profiting by another plant to support a vertical wall, it began laying the foundations of it; other ants having by this time arrived, finished in common what this had commenced."*

* Huber on Ants, p. 43.



M. Huber made most of his observations upon the processes followed by ants in glazed artificial hives or formicaries. The preceding figure represents a view of one of his formicaries of mason-ants.

We have ourselves followed up his observations, both on natural ant-hills and in artificial formicaries. On digging cautiously into a natural ant-hill, established upon the edge of a garden walk, we were enabled to obtain a pretty complete view of the interior structure. There were two stories, composed of large chambers, irregularly oval, communicating with each other by arched galleries, the walls of all which were as smooth and well polished as if they had been passed over by a plasterer's trowel. The floors of the chambers, we remarked, were by no means either horizontal or level, but all more or less sloped, and exhibiting in each chamber at least two slight

depressions of an irregular shape. We left the under story of this nest untouched, with the notion that the ants might repair the upper galleries, of which we had made a vertical section; but instead of doing so they migrated during the day to a large crack formed by the dryness of the weather, about a yard from their old nest. (J. R.)

We put a number of yellow ants (*Formica flava*), with their eggs and cocoons, into a small glass frame, more than half full of moist sand taken from their native hill, and placed in a sloping position, in order to see whether they would bring the nearly vertical, and therefore insecure, portion to a level by masonry. We were delighted to perceive that they immediately resolved upon performing the task which had been assigned them, though they did not proceed very methodically in their manner of building; for instead of beginning at the bottom and building upwards, many of them went on to add to the top of the outer surface, which increased rather than diminished the security of the whole. Withal, however, they seemed to know how far to go, for no portion of the newly-built wall fell; and in two days *they had not only reared a pyramidal mound to prop the*

rest, but had constructed several galleries and chambers for lodging the cocoons, which we had scattered at random amongst the sand. The new portion of this building is represented in the figure as supporting the upper and insecure parts of the nest.

We are sorry to record that our ingenious little masons were found upon the third day strewed about the outside of the building dead or dying, either from over fatigue or perhaps from surfeit, as we had supplied them with as much honey as they could devour. A small colony of tenants have at this moment (July 28th, 1829) taken possession of the premises of their own accord. (J. R.)

CHAPTER XV.

Wood-Ant or Pismire, and of Carpenter-Ants.

The largest of our British ants is that called the Hill-ant by Gould, the Fallow-ant by the English translator of Huber, and popularly the Pismire; but which we think may be more appropriately named the Wood-ant (*Formica rufa*, Latr.), from its invariable habit of living in or near woods and forests. This insect may be readily distinguished from other ants by the dusky black colour of its head and hinder parts, and the rusty brown of its middle. The structures reared by this species are often of considerable magnitude, and bear no small resemblance to a rook's nest thrown upon the ground bottom upwards. They occur in abundance in the woods near London, and in many other parts of the country: in Oak of Honour wood alone, we are acquainted with the localities of at least two dozen,—some in the interior and others on the hedge-banks on the outskirts of the wood. (J. R.)

The exterior of the nest is composed of almost every transportable material which the colonists can find in their vicinity: but the greater portion consists of the stems of withered grass and short twigs of trees, piled up in apparent confusion, but with sufficient regularity to render the whole smooth, conical, and sloping towards the base, for the purpose, we may infer, of carrying off rain water. When within reach of a corn-field, they often also pick up grains of wheat, barley, or oats, and carry them to the nest as building materials, and not for food, as was believed by the ancients. There are wonders enough observable in the economy of ants, without

having recourse to fancy—wonders which made Aristotle extol the sagacity of bloodless animals, and Cicero ascribe to them not only sensation, but mind, reason, and memory.* Ælian, however, describes, as if he had actually witnessed it, the ants ascending a stalk of growing corn, and throwing down "the ears which they bit off to their companions below." Aldrovand assures us that he had seen their granaries; and others pretend that they shrewdly bite off the ends of the grain to prevent it from germinating.† These are fables which accurate observation has satisfactorily contradicted.

But these errors, as it frequently happens, have contributed to a more perfect knowledge of the insects than we might otherwise have obtained; for it was the wish to prove or disprove the circumstance of their storing up and feeding upon grain, which led Gould to make his observations on English ants; as the notion of insects being produced *from* putrid carcases had before led Redi to his ingenious experiments on their generation. Yet, although it is more than eighty years since Gould's book was published, we find the error still repeated in very respectable publications.‡

The coping which we above described as forming the exterior of the wood-ant's nest, is only a small portion of the structure, which consists of a great number of interior chambers and galleries, with funnel-shaped avenues leading to them. The coping, indeed, is one of the most essential parts, and we cannot follow a more delightful guide than the younger Huber in detailing its formation.

"The labourers," he says, "of which the colony is composed, not only work continually on the outside of their nest, but, differing very essentially from other species, who willingly remain in the interior, sheltered

* In formicâ non modo sensus, sed etiam mens, ratio, memoria.

† Aldrovandus de Formicis, and Johnston, Thaumatogr. n. p. 356.

‡ See Professor Paxton's Illustn. of Scripture, i. 305.

they prefer living in the open air, and do not hesitate to carry on, even in our presence, the greater part of their operations.

"To have an idea how the straw or stubble-roof is formed, let us take a view of the ant-hill at its origin, when it is simply a cavity in the earth. Some of its future inhabitants are seen wandering about in search of materials fit for the exterior work, with which, though rather irregularly, they cover up the entrance; whilst others are employed in mixing the earth, thrown up in hollowing the interior, with fragments of wood and leaves, which are every moment brought in by their fellow-assistants; and this gives a certain consistence to the edifice, which increases in size daily. Our little architects leave here and there cavities, where they intend constructing the galleries which are to lead to the exterior, and as they remove in the morning the barriers placed at the entrance of their nest the preceding evening, the passages are kept open during the whole time of its construction. We soon observed the roof to become convex; but we should be greatly deceived did we consider it solid. This roof is destined to include many apartments or stories. Having observed the motions of these little builders through a pane of glass, adjusted against one of their habitations, I am thence enabled to speak with some degree of certainty upon the manner in which they are constructed. I ascertained that it is by excavating, or mining the under portion of their edifice, that they form their spacious halls, low indeed, and of heavy construction, yet sufficiently convenient for the use to which they are appropriated, that of receiving, at certain hours of the day, the larvæ and pupæ.

"These halls have a free communication by galleries, made in the same manner. If the materials of which the ant-hill is composed were only interlaced, they would fall into a confused heap every time the ants attempted to bring them into regular order. This, however, is obviated by their tempering the earth with rain-water, which, afterwards hardened in the sun, so completely and effectually binds together the several substances, as

to permit the removal of certain fragments from the ant-hill without any injury to the rest; it, moreover, strongly opposes the introduction of the rain. I never found, even after long and violent rains, the interior of the nest wetted to more than a quarter of an inch from the surface, provided it had not been previously out of repair, or deserted by its inhabitants.

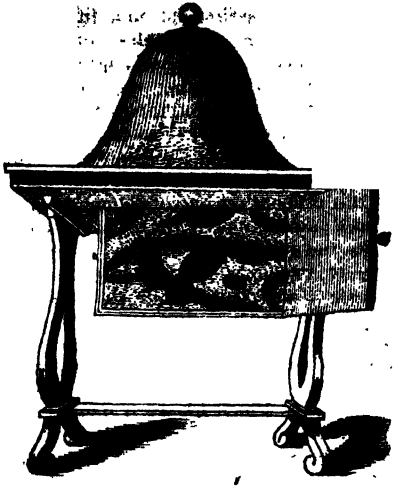
"The ants are extremely well sheltered in their chambers, the largest of which is placed nearly in the centre of the building; it is much loftier than the rest, and traversed only by the beams that support the ceiling; it is in this spot that all the galleries terminate, and this forms, for the most part, their usual residence.

"As to the underground portion, it can only be seen when the ant-hill is placed against a declivity; all the interior may be then readily brought in view, by simply raising up the straw roof. The subterranean residence consists of a range of apartments, excavated in the earth, taking an horizontal direction."*

M. P. Huber, in order to observe the operations of the wood-ant with more attention, transferred colonies of them to his artificial formicaries, plunging the feet of the stand into water to prevent their escape till they were reconciled to their abode, and had made some progress in repairing it. On the next page is a figure of the apparatus which he used for this purpose.

There is this remarkable difference in the nest of the wood-ants, that they do not construct a long covert way as if for concealment, as the yellow and the brown ants do. The wood-ants are not, like them, afraid of being surprised by enemies, at least during the day, when the whole colony is either foraging in the vicinity or employed on the exterior. But the proceedings of the wood-ants at night are well worthy of notice; and when M. Huber began to study their economy, he directed his entire attention to their night proceedings. "I remarked," says he, "that their habitations changed in appearance hourly, and that the diameter of those

* Huber on Ants, p. 15.



spacious avenues, where so many ants could freely pass each other during the day, was, as night approached, gradually lessened. The aperture, at length, totally disappeared, the dome was closed on all sides, and the ants retired to the bottom of their nest.

"In further noticing the apertures of these ant-hills, I fully ascertained the nature of the labour of its inhabitants, of which I could not before even guess the purport; for the surface of the nest presented such a constant scene of agitation, and so many insects were occupied in carrying materials in every direction, that the movement offered no other image than that of confusion.

"I saw then clearly that they were engaged in stopping up passages; and, for this purpose, they at first brought forward little pieces of wood, which they deposited near the entrance of those avenues they wished to close; they placed them in the stubble; they then went to seek other twigs and fragments of wood, which

they disposed above the first, but in a different direction, and appeared to choose pieces of less size in proportion as the work advanced. They, at length, brought in a number of dried leaves, and other materials of an enlarged form, with which they covered the roof: an exact miniature of the art of our builders, when they form the covering of any building? Nature, indeed, seems everywhere to have anticipated the inventions of which we boast, and this is doubtless one of the most simple.

"Our little insects, now in safety in their nest, retire gradually to the interior before the last passages are closed; one or two only remain without, or concealed behind the doors on guard, while the rest either take their repose, or engage in different occupations in the *most perfect security*. I was impatient to know what took place in the morning upon these ant-hills, and therefore visited them at an early hour. I found them in the same state in which I had left them the preceding evening. A few ants were wandering about on the surface of the nest, some others issued from time to time from under the margin of their little roofs formed at the entrance of the galleries: others afterwards came forth, who began removing the wooden bars that blockaded the entrance, in which they readily succeeded. This labour occupied them several hours. The passages were at length free, and the materials with which they had been closed scattered here and there over the ant-hill. Every day, morning and evening, during the fine weather, I was a witness to similar proceedings. On days of rain the doors of all the ant-hills remained closed. When the sky was cloudy in the morning, or rain was indicated, the ants, who seemed to be aware of it, opened but in part their several avenues, and immediately closed them when the rain commenced."*

The galleries and chambers which are roofed in as thus described, are very similar to those of the masonants, being partly excavated in the earth, and partly built with the clay thence procured. It is in these they

* Huber on Ants, p. 11.

pass the night, and also the colder months of the winter, when they become torpid, or nearly so, and of course require not the winter granaries of corn with which the ancients fabulously furnished them.

Carpenter-Ants.

The ants that work in wood perform much more extensive operations than any of the other carpenter insects which we have mentioned. Their only tools, like those of bees and wasps, are their jaws or mandibles; but though these may not appear so curiously constructed as the ovipositor file of the tree-hopper (*Cicada*), or the rasp and saw of the saw-flies (*Tenthredinidæ*), they are no less efficient in the performance of what is required. Among the carpenter-ants the emmet or jet-ant (*F. fuliginosa*) holds the first rank, and is easily known by being rather less in size than the wood-ant, and by its fine shining black colour. It is less common in Britain than some of the preceding, though its colonies may occasionally be met with in the trunks of decaying oak or willow trees in hedges.

"The labourers," says Huber, "of this species work always in the interior of trees, and are desirous of being screened from observation: thus every hope on our part is precluded of following them in their several occupations. I tried every expedient I could devise to surmount this difficulty; I endeavoured to accustom these ants to live and work under my inspection, but all my efforts were unsuccessful; they even abandoned the most considerable portion of their nest to seek some new asylum, and spurned the honey and sugar which I offered them for nourishment. I was now, by necessity, limited to the inspection only of their edifices; but, by decomposing some of the fragments with care, I hoped to acquire some knowledge of their organization.

"On one side I found horizontal galleries, hidden in great part by their walls, which follow the circular direction of the layers of the wood; and on another, parallel galleries, separated by extremely thin partitions, having no communication except by a few oval apertures.

Such is the nature of these works, remarkable for their delicacy and lightness.

"*In other fragments I found avenues which opened laterally, including portions of walls and transverse partitions, erected here and there within the galleries, so as to form separate chambers. When the work is further advanced, round holes are always observed, encased, as it were, between two pillars cut out in the same wall. These holes in course of time become square, and the pillars, originally arched at both ends, are worked into regular columns by the chisel of our sculptors. This, then, is the second specimen of their art. This portion of the edifice will probably remain in this state.*

"But in another quarter are fragments differently wrought, in which these same partitions, pierced now in every part, and hewn skilfully, are transformed into colonnades, which sustain the upper stories, and leave a free communication throughout the whole extent. It can readily be conceived how parallel galleries, hollowed out upon the same plan, and the sides taken down, leaving only from space to space what is necessary to sustain their ceilings, may form an entire story; but as each has been pierced separately, the flooring cannot be very level: this, however, the ants turn to their advantage, since these furrows are better adapted to retain the larvæ that may be placed there.

"The stories constructed in the great roots offer greater irregularity than those in the very body of the tree, arising either from the hardness and interlacing of the fibres, which renders the labour more difficult, and obliges the labourers to depart from their accustomed manner, or from their not observing in the extremities of their edifice the same arrangement as in the centre; whatever it be, horizontal stories and numerous partitions are still found. If the work be less regular it becomes more delicate; for the ants, profiting by the hardness and solidity of the materials, give to their building an extreme degree of lightness. I have seen fragments of from eight to ten inches in length, and of equal height, formed of wood as thin as paper, containing a number of

Portion of a Tree, with Chambers and Galleries chiseled out by Jet-Ants.

apartments, and presenting a most singular appearance. At the entrance of these apartments, worked out with so much care, are very considerable openings; but in place of chambers and extensive galleries, the layers of the wood are hewn in arcades, allowing the ants a free passage in every direction. These may be regarded as the gates or vestibules conducting to the several lodges." *

It is a singular circumstance in the structures of these ants, that all the wood which they carve is tinged of a black colour, as if it were smoked; and M. Huber was not a little solicitous to discover whence this arose. It certainly does not add to the beauty of their streets, which look as sombre as the most smoke-dyed walls in the older lanes of the metropolis. M. Huber could not satisfy himself whether it was caused by the exposure of the wood to the atmosphere, by some emanation from the ants, or by the thin layers of wood being acted upon or decomposed by the formic acid.† But if any or all of these causes operated in blackening the wood, we should be ready to anticipate a similar effect in the case

* Huber, p. 56. † The acid of ants.

of other species of ants which inhabit trees; yet the black tint is only found in the excavations of the jet-ant.

We are acquainted with several colonies of the jet-ants,—one of which, in the roots and trunk of an oak on the road from Lewisham to Sydenham, near Brockley, in Kent, is so extremely populous, that the numbers of its inhabitants appeared to us beyond any reasonable estimate. None of the other colonies of this species which we have seen appear to contain many hundreds. *On cutting into the root of the before-mentioned tree, we found the vertical excavations of much larger dimensions, both in width and depth, than those represented by Huber in the preceding cut (page 34). What surprised us the most was to see the tree growing vigorously and fresh, though its roots were chiseled in all directions by legions of workers, while every leaf, and every inch of the bark, was also crowded by parties of foragers. On one of the low branches we found a deserted nest of the white-throat (*Sylvia cinerea*, Temminck), in the cavity of which they were piled upon one another as close as the unhappy negroes in the hold of a slave-ship; but we could not discover what had attracted them hither. Another dense group, collected on one of the branches, led us to the discovery of a very singular oak gall, formed on the bark in the shape of a pointed cone, and crowded together. It is probable that the juice which they extracted from these galls was much to their taste. (J. R.)

Beside the jet-ant, several other species exercise the art of carpentry,—nay, what is more wonderful still, they have the ingenuity to knead up, with spiders'-web for a cement, the chips which they chisel out into a material with which they construct entire chambers. The species which exercise this singular art are the Ethiopian (*Formica nigra*) and the yellow ant (*F. flava*).*

We once observed the dusky ants (*F. fusca*), at Blackheath, in Kent, busily employed in carrying out

* Huber.

chips from the interior of a decaying black poplar, at the root of which a colony was established; but, though it thence appears that this species can chisel wood if they choose, yet they usually burrow in the earth, and by preference, as we have remarked, at the root of a tree, the leaves of which supply them with food.

Among the foreign ants we may mention a small yellow ant of South America, described by Dampier, which seems, from his account, to construct a nest of green leaves. "Their sting," he says, "is like a spark of fire; and they are so thick among the boughs in some places, that one shall be covered with them before he is aware. These creatures have nests on great trees, placed on the body between the limbs: some of their nests are as big as a hogshead. This is their winter habitation; for in the wet season they all repair to these their cities, where they preserve their eggs. In the dry season, when they leave their nests, they swarm all over the woodlands, for they never trouble the savannahs. Great paths, three or four inches broad, made by them, may be seen in the woods. They go out light, but bring home heavy loads on their backs, all of the same substance, and equal in size. I never observed anything besides pieces of green leaves, so big that I could scarcely see the insect for his burthen; yet they would march stoutly, and so many were pressing forward that it was a very pretty sight, for the path looked perfectly green with them."

Ants observed in New South Wales, by the gentlemen in the expedition under Captain Cook, are still more interesting. "Some," we are told, "are as green as a leaf, and live upon trees, where they build their nests of various sizes, between that of a man's head and his fist. These nests are of a very curious structure: they are formed by bending down several of the leaves, each of which is as broad as a man's hand, and gluing the points of them together, so as to form a purse. The viscous matter used for this purpose is an animal juice

which nature has enabled them to elaborate. Their method of first bending down the leaves we had no *opportunity to observe; but we saw thousands uniting all their strength to hold them in this position, while other busy multitudes were employed within in applying* this gluten that was to prevent their returning back." To satisfy ourselves that the leaves were bent and held down by the efforts of these diminutive artificers, we disturbed them in their work; and as soon as they were driven from their stations, the leaves on which they were employed sprang up with a force much greater than we could have thought them able to conquer by any combination of their strength. But, though we gratified our curiosity at their expense, the injury did not go unrevenged; for thousands immediately threw themselves upon us, and gave us intolerable pain with their stings, especially those which took possession of our necks and hair, from whence they were not easily driven. Their sting was scarcely less painful than that of a bee; but, except it was repeated, the pain did not last more than a minute.

"Another sort are quite black, and their operation and manner of life are not less extraordinary. Their habitations are the inside of the branches of a tree, which they contrive to excavate by working out the pith almost to the extremity of the slenderest twig, the tree at the same time flourishing as if it had no such inmate. When we first found the tree we gathered some of the branches; and were scarcely less astonished than we should have been to find that we had profaned a consecrated grove, where every tree, upon being wounded, gave signs of life; for we were instantly covered with legions of these animals, swarming from every broken bough, and inflicting their stings with incessant violence.

"A third kind we found nested in the root of a plant, which grows on the bark of trees in the manner of mistletoe, and which they had perforated for that use. This root is commonly as big as a large turnip, and sometimes much bigger. When we cut it, we found it intersected by innumerable winding passages, all filled

with these animals, by which, however, the vegetation of the plant did not appear to have suffered any injury. We never cut one of these roots that was not inhabited, though some were not bigger than a hazel-nut. The animals themselves are very small, not more than half as big as the common red ant in England. They had stings, but scarcely force enough to make them felt: they had, however, a power of tormenting us in an equal, if not in a greater degree; for the moment we handled the root, they swarmed from innumerable holes, and running about those parts of the body that were uncovered, produced a titillation more intolerable than pain, except it is increased to great violence." *

The species called sugar-ants in the West Indies are particularly destructive to the sugar-cane, as well as to lime, lemon, and orange-trees, by excavating their nests at the roots, and so loosening the earth that they are frequented uprooted and blown down by the winds. If this does not happen, the roots are deprived of due nourishment, and the plants become sickly and die.†

* Hawkesworth's Account of Cook's First Voyage.

† Phil. Trans., xxx., p. 346.

CHAPTER XVI.

Structures of White Ants, or Termites.

WHEN we look back upon the details which we have given of the industry and ingenuity of numerous tribes of insects, both solitary and social, we are induced to think it almost impossible that they could be surpassed. The structures of wasps and bees, and still more those of the wood-ant (*Formica rufa*), when placed in comparison with the size of the insects, equal our largest cities compared with the stature of man. But when we look at the buildings erected by the white ants of tropical climates, all that we have been surveying dwindles into insignificance. Their industry appears greatly to surpass that of our ants and bees, and they are certainly more skilful in architectural contrivances. The elevation, also, of their edifices is more than five hundred times the height of the builders. Were our houses built according to the same proportions, they would be twelve or fifteen times higher than the London Monument, and four or five times higher than the pyramids of Egypt, with corresponding dimensions in the basements of the edifices. These statements are, perhaps, necessary to impress the extraordinary labours of ants upon the mind; for we are all more or less sensible to the force of comparisons. The analogies between the works of insects and of men are not perfect; for insects are all provided with instruments peculiarly adapted to the end which they instinctively seek, while man has to form a plan by progressive thought and upon the experience of others, and to complete it with tools which he also invents.

The termites do not stand above a quarter of an inch high, while their nests are frequently twelve feet; and

Jobson mentions some which he had seen as high as twenty feet; "of compass," he adds, "to contain a dozen men, with the heat of the sun baked into that hardness, that we used to hide ourselves in the ragged tops of them when we took up stands to shoot at deer or wild beasts."* Bishop Heber saw a number of these high ant-hills in India, near the principal entrance of the Sooty or Moorshedabad river. "Many of them," he says, "were five or six feet high, and probably seven or eight feet in circumference at the base, partially overgrown with grass and ivy, and looking at a distance like the stumps of decayed trees. I think it is Ctesias, among the Greek writers, who gives an account alluded to by Lucian, in his 'Cock,' of monstrous ants in India, as large as foxes. The falsehood probably originated in the stupendous fabrics which they rear here, and which certainly might be supposed to be the work of a much larger animal than their real architect."† Herodotus has a similar fable of the enormous size and brilliant appearance of the ants of India.

Nor is it only in constructing dwellings for themselves that the termites of Africa and of other hot climates employ their masonic skill. Though, like our ants and wasps, they are almost omnivorous, yet wood, particularly when felled and dry, seems their favourite article of food; but they have an utter aversion to feeding in the light, and always eat their way with all expedition into the interior. It thence would seem necessary for them either to leave the bark of a tree, or the outer portion of the beam or door of a house, undevoured, or to eat in open day. They do neither; but are at the trouble of constructing galleries of clay, in which they can conceal themselves, and feed in security. In all their foraging excursions, indeed, they build covert ways, by which they can go out and return to their encampment.‡

* Jobson's Gambia, in Purchas's Pilgrim, ii. p. 1570.
† Heber's Journal, vol. i. p. 248.
‡ Smeathman, in Phil. Trans., vol. lxxi.

Others of the species (for there are several), instead of building galleries, exercise the art of miners, and make their approaches under ground, penetrating beneath the foundation of houses or areas, and rising again either through the floors, or by entering the bottom of the posts that support the building, when they follow the course of the fibres, and make their way to the top, boring holes and cavities in different places, as they proceed. Multitudes enter the roof, and intersect it with pipes or galleries, formed of wet clay; which serve for passages in all directions, and enable them more readily to fix their habitations in it. They prefer the softer woods, such as pine and fir, which they hollow out with such nicety, that they leave the surface whole, after having eaten away the inside. A shelf or plank attacked in this manner, looks solid to the eye, when, if weighed, it will not out-balance two sheets of pasteboard of the same dimensions. It sometimes happens that they carry this operation so far on stakes in the open air, as to render the bark too flexible for their purpose; when they remedy the defect by plastering the whole stick with a sort of mortar which they make with clay; so that, on being struck, the form vanishes, and the artificial covering falls in fragments on the ground. In the woods, when a large tree falls from age or accident, they enter it on the side next the ground, and devour it at leisure, till little more than the bark is left. But in this case they take no precaution of strengthening the outward defence, but leave it in such a state as to deceive an eye unaccustomed to see trees thus gutted of their insides; and "you may as well," says Mr. Smeathman, "step upon a cloud." It is an extraordinary fact, that when these creatures have formed pipes in the roof of a house, instinct directs them to prevent its fall, which would ensue from their having sapped the posts on which it rests; but as they gnaw away the wood, they fill up the interstices with clay, tempered to a surprising degree of hardness; so that, when the house is pulled down, these posts are transformed from wood to stone. They make the walls of their galleries of the same com-

position as their nests, varying the material according to their kind: one species uses red clay, another black clay, and a third a kind of [illegible] cemented with gums, for a security from the attacks of their enemies, particularly the ant, which, being defended by a strong, horny shell, is more than a match for them; and when it can get at them, rapaciously seizes them, and drags them to its nest for food for its young brood. If any accident breaks down part of their walls, they repair the breach with all speed. Instinct guides them to perform their office in the creation, by mostly confining their attacks to trees that are beginning to decay, or such timber as has been severed from its root for use, and would decay in time. Vigorous, healthy trees do not require to be destroyed, and, accordingly, these consumers have no taste for them.*

M. Adanson describes the termites of Senegal as constructing covert ways along the surface of wood which they intend to attack; but though we have no reason to distrust so excellent a naturalist, in describing what he saw, it is certain that they more commonly eat their way into the interior of the wood, and afterwards form the galleries, when they find that they have destroyed the wood till it will no longer afford them protection.

But it is time that we should come to their principal building, which may, with some propriety, be called a city; and, according to the method we have followed in other instances, we shall trace their labours from the commencement. We shall begin with the operations of the species which may be appropriately termed the Warrior (*Termes fatalis*, LINN.; *T. bellicosus*, SMEATH.)

We must premise, that though they have been termed white *ants*, they do not belong to the same order of insects with our ants; yet they have a slight resemblance to ants in their form, but more in their economy. Smeathman, to whom we owe our chief knowledge of the genus, describes them as consisting of kings, queens, soldiers, and workers, and is of opinion that the workers

* Smeathman.

Termes bellicosus in the winged state.

are larvæ, the soldiers nymphæ, and the kings and queens the perfect insects. In this opinion he coincides with Sparrmann* and others; but Latreille is inclined to think, from what he observed in a European species (*Termes lucifugus*), found near Bordeaux, that the soldiers form a distinct race, like the neuter workers among bees and ants, while the working termites are larvæ,† which are furnished with strong mandibles for gnawing; when they become nymphs, the rudiments of four wings appear, which are fully developed in the perfect insects. In this state, they migrate to form new colonies, but the greater number of them perish in a few hours, or become the prey of birds, and even the natives, who fry them as delicacies. "I have discoursed with several gentlemen," says Smeathman, "upon the taste of the white ants, and on comparing notes, we have always agreed that they are most delicious and delicate eating. One gentleman compared them to sugared marrow, another to sugared cream and a paste of sweet almonds."‡

Mr. Smeathman's very interesting paper affords us the most authentic materials for the further description of these wonderful insects; and we therefore continue partly to extract from, and partly to abridge, his account.

* Quoted by De Geer, vol. vii.

† Hist. Nat. Générale, vol. xiii. p. 66.

‡ Smeathman, in Phil. Trans. vol. lxxi. p. 169, not

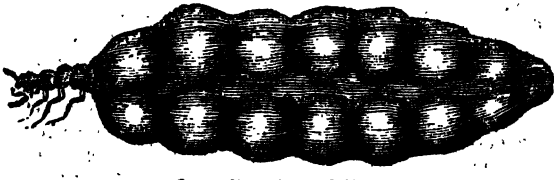
The few pairs that are so fortunate as to survive the various casualties that assail them, are usually found by workers (larvæ), which, at this season, are running continually on the surface of the ground, on the watch for them. As soon as they discover the objects of their search, they begin to protect them from their surrounding enemies, by inclosing them in a small chamber of clay, where they become the parents of a new community, and are distinguished from the other inhabitants of the nest, by the title of king and queen. Instinct directs the attention of these labouring insects to the preservation of their race, in the protection of this pair and their offspring. The chamber that forms the rudiment of a new nest is contrived for their safety, but the entrances to it are too small to admit of their ever leaving it; consequently, the charge of the eggs devolves upon the labourers, who construct nurseries for their reception. These are small, irregularly-shaped chambers, placed at first round the apartment of the king and queen, and not exceeding the size of a hazel-nut; but in nests of long standing they are of great comparative magnitude, and distributed at a greater distance. The receptacles for hatching the young are all composed of wooden materials, apparently joined together with gum, and, by way of defence, cased with clay. The chamber that contains the king and queen is nearly on a level with the surface of the ground; and as the other apartments are formed about it, it is generally situated at an equal distance from the sides of the nest, and directly beneath its conical point. Those apartments which consist of nurseries and magazines of provisions, form an intricate labyrinth, being separated by small, empty chambers and galleries, which surround them, or afford a communication from one to another. This labyrinth extends on all sides to the outward shells, and reaches up within it to two-thirds or more of its height, leaving an open area above, in the middle, under the dome, which reminds the spectator of the nave of an old cathedral. Around this are raised three or four large arches, which are sometimes two or three feet high, next the front of the area, but

diminish as they recede further back, and are lost amidst the innumerable chambers and nurseries behind them.

Every one of these buildings consists of two distinct parts, the exterior and the interior. The exterior is one large shell, in the manner of a dome, large and strong enough to inclose and shelter the interior from the vicissitudes of the weather, and the inhabitants from the attacks of natural or accidental enemies. It is always, therefore, much stronger than the interior building, which is the habitable part, divided, with a wonderful kind of regularity and contrivance, into an amazing number of apartments for the residence of the king and queen, and the nursing of the numerous progeny; or for magazines, which are always found well filled with stores and provisions. The hills make their first appearance *above ground by a little turret or two, in the shape of sugar-loaves, which* are run a *foot high* or more. Soon after, at some little distance, while the former are increasing in height and size, they raise others, and so go on increasing their number, and widening them at the base, till their works below are covered with these turrets, of which they always raise the highest and largest in the middle, and, by filling up the intervals between each turret, collect them into one dome. They are not very curious or exact in the workmanship, except in making them very solid and strong; and when, by their joining them, the dome is completed, for which purpose the turrets answer as scaffolds, they take away the middle ones entirely, except the tops, which, joined together, make the crown of the cupola, and apply the clay to the building of the works within, or to erecting fresh turrets for the purpose of raising the hillock still higher; so that some part of the clay is probably used several times, like the boards and posts of a mason's scaffolds.

When these hills are little more than half their height, it is a common practice of the wild bulls to stand as sentinels on them, while the rest of the herd are ruminating below. They are sufficiently strong for that purpose; and at their full height, answer excellently well as places of look-out; and Mr. Smeathman has been, with four

more, on the top of one of these hillocks, to watch for a vessel in sight. The outward shell, or dome, is not only of use to protect and support the interior buildings from external violence and the heavy rains, but to collect and preserve a regular degree of the warmth and moisture necessary for hatching the eggs and cherishing the young. The royal chamber occupied by the king and queen appears to be, in the opinion of this little people, of the most consequence, being always situated as near the centre of the interior building as possible. It is always nearly in the shape of half an egg, or an obtuse oval, within, and may be supposed to represent a long oven. In the infant state of the colony, it is but about an inch in length; but in time will be increased to six or eight inches, or more, in the clear, being always in proportion to the size of the queen, who, increasing in bulk as in age, at length requires a chamber of such dimensions.



Queen distended with Eggs.

Its floor is perfectly horizontal, and, in large hillocks, sometimes more than an inch thick of solid clay. The roof, also, which is one solid and well-turned oval arch, is generally of about the same solidity, but in some places it is not a quarter of an inch thick, on the sides where it joins the floor, and where the doors or entrances are made level with it, at nearly equal distances from each other. These entrances will not admit any animal larger than the soldiers or labourers; so that the king and the queen (who is, at full size, a thousand times the weight of a king) can never possibly go out, but remain close prisoners.

The royal chamber, if in a large hillock, is surrounded

by a countless number of others, of different sizes, shapes, and dimensions; but all of them arched in one way or another—sometimes elliptical or oval. These either open into each other, or communicate by passages as wide as, and are evidently made for, the soldiers and attendants, of whom great numbers are necessary, and always in waiting. These apartments are joined by the magazines and nurseries. The former are chambers of clay, and are always well filled with provisions, which, to the naked eye, seem to consist of the raspings of wood, and plants which the termites destroy; but are found by the microscope to be principally the gums or inspissated juices of plants. These are thrown together in little masses, some of which are finer than others, and resemble the sugar about preserved fruits; others are like tears of gum, one quite transparent, another like amber, a third brown, and a fourth quite opaque, as we see often in parcels of ordinary gums. These magazines are intermixed with the nurseries, which are buildings totally different from the rest of the apartments; for these are composed entirely of wooden materials, seemingly joined together with gums. Mr. Smeathman calls them the nurseries, because they are invariably occupied by the eggs and young ones, which appear at first in the shape of labourers, but white as snow. These buildings are exceedingly compact, and divided into many very small irregular-shaped chambers, not one of which is to be found of half an inch in width. They are placed all round, and as near as possible to the royal apartments.

When the nest is in the infant state, the nurseries are close to the royal chambers; but as, in process of time, the queen enlarges, it is necessary to enlarge the chamber for her accommodation; and as she then lays a greater number of eggs, and requires a greater number of attendants, so it is necessary to enlarge and increase the number of the adjacent apartments; for which purpose the small nurseries which are first built are taken to pieces, rebuilt a little further of a size larger, and the number of them increased at the same time. Thus they continually enlarge their apartments, pull down, repair,

or rebuild, according to their wants, with a degree of sagacity, regularity, and foresight, not even imitated by any other kind of animals or insects.

All these chambers, and the passages leading to and from them, being arched, they help to support each other; and while the interior large arches prevent them from falling into the centre, and keep the area open, the exterior building supports them on the outside. There are, comparatively speaking, few openings into the great area, and they, for the most part, seem intended only to admit into the nurseries that genial warmth which the dome collects. The interior building, or assemblage of nurseries, chambers, &c., has a flattish top or roof, without any perforation, which would keep the apartments below dry, in case through accident the dome should receive any injury, and let in water; and it is never exactly flat and uniform, because the insects are always adding to it by building more chambers and nurseries; so that the division or columns between the future arched apartment resemble the pinnacles on the fronts of some old buildings, and demand particular notice, as affording one proof that for the most part the insects project their arches, and do not make them by excavation. The area has also a flattish floor, which lies over the royal chamber, but sometimes a good height above it, having nurseries and magazines between. It is likewise waterproof, and contrived to let the water off if it should get in, and run over by some short way into the subterraneous passages, which run under the lowest apartments in the hill in various directions, and are of an astonishing size, being wider than the bore of a great cannon. One that Mr. Smeathman measured was perfectly cylindrical, and thirteen inches in diameter. These subterraneous passages, or galleries, are lined very thick with the same kind of clay of which the hill is composed, and ascend the inside of the outward shell in a spiral manner; and winding round the whole building up to the top, intersect each other at different heights, opening either immediately in the dome in various places, and into the interior building, the new turrets, &c., or communicating

with them by other galleries of different diameters, either circular or oval.

From every part of these large galleries are various small covert ways, or galleries leading to different parts of the building. Under ground there are a great many that lead downward by sloping descents, three and four feet perpendicular among the gravel, whence the workers cull the finer parts, which, being kneaded up in their mouths to the consistence of mortar, become that solid clay or stone of which their hills and all their buildings, except their nurseries, are composed. Other galleries again ascend, and lead out horizontally on every side, and are carried under ground near to the surface a vast distance: for if all the nests are destroyed within a hundred yards of a house, the inhabitants of those which are left unmolested farther off, will still carry on their subterraneous galleries, and, invading it by sap and mine, do great mischief to the goods and merchandises contained in it.

It seems there is a degree of necessity for the galleries under the hills being thus large, since they are the great thoroughfares for all the labourers and soldiers going forth or returning, whether fetching clay, wood, water, or provisions; and they are certainly well calculated for the purposes to which they are applied by the spiral slope which is given them; for if they were perpendicular, the labourers would not be able to carry on their building with so much facility, as they ascend a perpendicular with great difficulty, and the soldiers can scarcely do it at all. It is on this account that sometimes a road like a ledge is made on the perpendicular side of any part of the building within their hill, which is flat on the upper surface and half an inch wide, and ascends gradually like a staircase, or like those winding roads which are cut on the sides of hills and mountains, that would otherwise be inaccessible; by which and similar contrivances they travel with great facility to every interior part.

This, too, is probably the cause of their building a kind of bridge of one great arch, which answers the purpose of a flight of stairs from the floor of the area, to

a, A covered way and nest, on the branch of a tree, of the *Termites arborum*. *b*, Section of the Hill-nest of the *Termites bellicosi*, to shew the interior. *c*, Hill-nest of the *Termites bellicosi*, entire.

one opening on the side of one of the columns that support the great arches. This contrivance must shorten the distance surprisingly to those labourers who have the eggs to carry from the royal chamber to some of the upper ancteries, which in some hills would be four or five feet in the straightest line, and much more if carried through all the winding passages leading through the lower chambers and apartments. Mr. Smeathman found one of these bridges, half an inch broad, a quarter of an inch thick, and ten inches long, making the side of an elliptic arch of proportionable size; so that it is wonderful it did not fall over or break by its own weight before they got it joined to the side of the column above.

It was strengthened by a small arch at the bottom, and had a hollow or groove all the length of the upper surface, either made purposely for the inhabitants to travel over with more safety, or else, which is not improbable, worn by frequent treading.

Turret-Building White Ants.

Apparently more than one species smaller than the preceding, such as the *Termes mordax* and *T. atrox* of Smeathman, construct nests of a very different form, the figures of which resemble a pillar, with a large mushroom for a capital. These turrets are composed of well-tempered black earth, and stand nearly three feet high. The conical mushroom-shaped roof is composed of the same material, and the brims hang over the column, being four or five inches wider than its perpendicular sides. Some of them, says Smeathman, resemble in shape the cap of a round windmill, but some of the roofs have a double elevation in the middle. When one of these turrets is completed, the insects do not afterwards enlarge or alter it; but if it be found too small for them, they build the foundation of another at a few inches' distance. They sometimes, but not often, begin the second before the first is finished, and a third before they have completed the second. Five or six of these singular turrets in a group may be seen in the thick woods at the foot of

a tree. They are so very strongly built, that in case of violence, they will sooner tear up the gravel and solid heart of their foundation than break in the middle. When any of them happen to be thus thrown down, the insects do not abandon them: but, using their over-turned column as a basis, they run up another perpendicularly from it to the usual height, fastening the under part at the same time to the ground, to render it the more secure.

Turret Nests of White Ants. One nest is represented cut through, with the upper part lying on the ground.

The interior of a turret is pretty equally divided into innumerable cells, irregular in shape, but usually more or less angular, generally quadrangular or pentagonal, though the angles are not well defined. Each shell has at least two entrances; but there are no galleries, arches, nor wooden nurseries, as in the nests of the warrior (*T. bellicosus*). The two species which build turret nests are very different in size, and the dimensions of the nests differ in proportion.

The White Ants of Trees

Latreille's species of white ant (*Termes lucifugus*, Rossi), formerly mentioned as found in the south of Europe, appear to have more the habits of the jet ant, described page 32, than their congeners of the tropics. They live in the interior of the trunks of trees, the wood of which they eat, and form their habitations of the galleries which they thus excavate. M. Latreille says they appear to be furnished with an acid for the purpose of softening the wood, the odour of which is exceedingly pungent. They prefer the part of the wood nearest to the bark, which they are careful not to injure, as it affords them protection. All the walls of their galleries are moistened with small globules of a gelatinous substance, similar to gum Arabic. They are chiefly to be found in the trunks of oak and pine trees, and are very numerous.*

Another of the species (*Termes arborum*), described by Smeathman, builds a nest on the exterior of trees, altogether different from any of the preceding. These are of a spherical or oval shape, occupying the arm or branch of a tree sometimes from seventy to eighty feet from the ground, and as large, in a few instances, as a sugar-cask. The composition used for a building material is apparently similar to that used by the warriors for constructing their nurseries, being the gnawings of wood in very small particles, kneaded into a paste with some species of cement or glue, procured, as Smeathman supposes, partly from gummiferous trees, and partly from themselves; but it is more probable, we think, that it is wholly secreted, like the wax of bees, by the insects themselves. With this cement, whatever may be its composition, they construct their cells, in which there is nothing very wonderful except their great numbers. They are very firmly built, and so strongly attached to the trees, that they will resist the most violent tornado. It is impossible, indeed, to detach them, except by

* Latreille, Hist. Nat. Générale, tom. xiii. p. 64.

cutting them in pieces, or sawing off the branch, which is frequently done to procure the insects for young turkeys. (See engraving, p. 50, for a figure of this nest.)

This species very often, instead of selecting the bough of a tree, builds in the roof or wall of a house, and unless observed in time, and expelled, occasions considerable damage. It is easier, in fact, to shut one's door against a fox or a thief, than to exclude such insidious enemies, whose aversion to light renders it difficult to trace them even when they are numerous.

If we reflect on the prodigious numbers of those insects, and their power and rapidity of destroying, we cannot but admire the wisdom of Providence in creating so indefatigable and useful an agent in countries where the decay of vegetable substances is rapid in proportion to the heat of the climate. We have already remarked that they always prefer decaying or dead timber; and it is indeed a very general law among insects which feed on wood to prefer what is unsound: the same principle holds with respect to fungi, lichens, and other parasitical plants.

All the species of Termites are not social; but the solitary ones do not, like their congeners, distinguish themselves in architecture. In other respects, their habits are more similar; for they destroy almost every substance, animal and vegetable. The most common of the solitary species must be familiar to all our readers by the name of wood-louse (*Termes pulsatorium*, Linn.; *Atropos lignarius*, Leach)—one of the insects which produces the ticking superstitiously termed the *death-watch*. It is not so large as the common louse, but whiter and more slender, having a red mouth and yellow eyes. It lives in old books, the paper on walls, collections of insects and dried plants, and is extremely agile in its movements, darting, by jerks, into dark corners for the purpose of concealment. It does not like to run straight forward without resting every half-second, as if to listen or look about for its pursuer, and at such resting times it is easily taken. The ticking noise is made by

the insect beating against the wood with its head, and it is supposed by some to be peculiar to the female, and to be connected with the laying of her eggs. M. Latreille, however, thinks that the wood-louse is only the grub of the *Psocus abdominalis*, in which case it could not lay eggs; but this opinion is somewhat questionable. Another death-watch is a small beetle (*Anobium tesselatum*).

CHAPTER XVII.

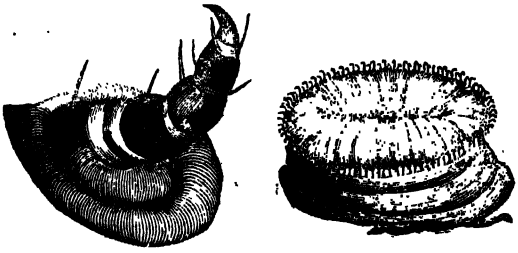
Structures of Silk spun by Caterpillars, including the Silk-Worm.

"Millions of spinning-worms,
That in their green shops weave the smooth-hair'd silk."
MILTON'S *Comus*.

ALL the caterpillars of butterflies, moths, and, in general, of insects with four wings, are capable of spinning silk, of various degrees of fineness and strength, and differing in colour, but usually white, yellow, brown, black, or grey. This is not only of advantage in constructing nests for themselves, and particularly for their pupæ, as we have so frequently exemplified in the preceding pages, but it enables them, the instant they are excluded from the egg, to protect themselves from innumerable accidents, as well as from enemies. If a caterpillar, for instance, be exposed to a gust of wind, and blown off from its native tree, it lets itself gently down, and breaks its fall, by immediately spinning a cable of silk, along which, also, it can reascend to its former station when the danger is over. In the same way, it frequently disappoints a bird that has marked it out for prey, by dropping hurriedly down from a branch, suspended to its never-failing delicate cord. The leaf-rollers, formerly described, have the advantage of other caterpillars in such cases, by being able to move as quickly backwards as forwards; so that when a bird puts in its bill at one end of the roll, the insect makes a ready exit at the other, and drops

along its thread as low as it judges convenient. We have seen caterpillars drop in this way from one to six feet or more; and by means of their cable, which they are careful not to break, they climb back with great expedition to their former place.

The structure of their legs is well adapted for climbing up their singular rope—the six fore-legs being furnished with a curved claw; while the pro-legs (as they have been termed) are no less fitted for holding them firm to the branch when they have regained it, being constructed on the principle of forming a vacuum, like the leather sucker with which boys lift and drag stones. The foot of the common fly has a similar sucker, by which it is enabled to walk on glass, and otherwise support itself against gravity. The different forms of the leg and pro-leg of a spinning caterpillar are represented in the figure.



Leg and Pro-leg of a Caterpillar, greatly magnified.

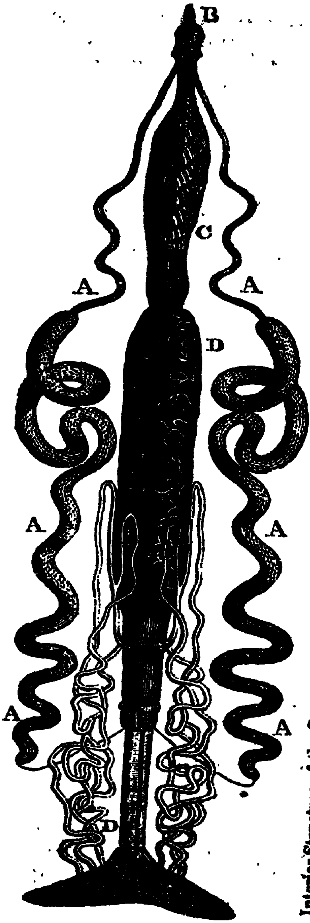
In order to understand the nature of the apparatus by which a caterpillar spins its silk, it is to be recollected that its whole interior structure differs from that of warm-blooded animals. It has, properly speaking, no heart, though a long tubular *dorsal vessel*, which runs along the back, and pulsates from twenty to one hundred times per minute, has been called so by Malpighi and others: but neither Lyonnet nor Cuvier could detect any vessel issuing from it; and consequently the fluid which is analogous to blood has no circulation. It differs also

from the higher orders of animals in having no brain, the nerves running along the body being only united by little knobs, called ganglions. Another circumstance is, that it has no lungs, and does not breathe by the mouth, but by air-holes, or spiracles, eighteen in number, situated along the sides, in the middle of the rings, as may be seen in the following figure from Lyonnet.

Caterpillar of the Goat-Moth (*Cossus ligniperda*).

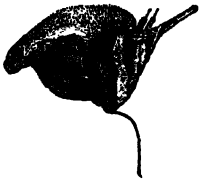
These spiracles communicate on each side with tubes, that have been called the wind-pipes (*tracheæ*). The spinning apparatus is placed near the mouth, and is connected with the silk-bags, which are long, slender, floating vessels, containing a liquid gum. The bags are closed at their lower extremity, become wider towards the middle, and more slender towards the head, where they unite to form the spinning-tube, or spinneret. The bags being in most cases longer than the body of the caterpillar, necessarily lie in a convoluted state, like the intestines of quadrupeds. The capacity, or rather the length, of the silk-bags, is in proportion to the quantity of silk required for spinning; the *Cossus ligniperda*, for example, from living in the wood of trees spins little, having a bag only one-fourth the length of that of the silk-worm, though the caterpillar is at least twice the dimensions of the latter. The following figure, taken from the admirable treatise of Lyonnet on the anatomy of the *Cossus*, will render these several organs more easily understood than any description.

The spinneret itself was supposed by Réaumur to have two outlets for the silk; but Lyonnet, upon minute dissection, found that the two tubes united into one before their termination; and he also almost assured himself that it was composed of alternate slips of horny and



Interior Structure of the Cossus.—A. silk bags; B. silk tube, through which the viscid matter, of which the silk threads are formed, is forced by a peristaltic motion; C. stomach; D. D. intestines, with the coil of bile vessels.

membranaceous substance,—the one for pressing the thread into a small diameter, and the other for enlarging it at the insect's pleasure. It is cut at the end somewhat like a writing-pen, though with less of a slope, and is admirably fitted for being applied to objects to which it may be required to attach silk. The following are magnified figures of the spinneret of the *Cossus*, from Lyonnet.

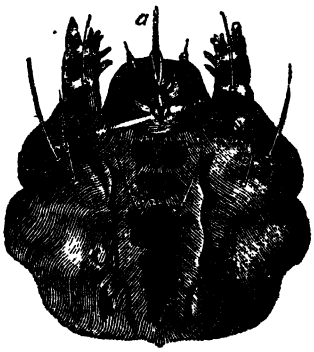


Side-view of the Silk-tube.

Section of the Silk-tube, magnified 22,000 times.

"You may sometimes have seen," says the Abbé de la Pluche, "in the work-rooms of goldsmiths or gold-wire-drawers, certain iron plates, pierced with holes of different calibres, through which they draw gold and silver wire, in order to render it finer. The silk-worm has under her mouth such a kind of instrument, perforated with a pair of holes [united into one on the outside*], through which she draws two drops of the gum that fills her two bags. These instruments are like a pair of distaffs for spinning the gum into a silken thread. She fixes the first drop of gum that issues where she pleases, and then draws back her head, or lets herself fall, while the gum, continuing to flow, is drawn out and lengthened into a double stream. Upon being exposed to the air, it immediately loses its fluidity, becomes dry, and acquires consistence and strength. She is never deceived in adjusting the dimensions of the [united] apertures, or in calculating the proper thickness of the

* Lyonnet.



Labium, or lower lip of Cossus.—*a*. Silk-tube.

thread, but invariably makes the strength of it proportionable to the weight of her body.

"It would be a very curious thing to know how the gum which composes the silk is separated and drawn off from the other juices that nourish the animal. It must be accomplished like the secretions formed by glands in the human body. I am therefore persuaded that the gum-bags of the silk-worm are furnished with a set of minute glands, which, being impregnated with gum, afford a free passage to all the juices of the mulberry-leaf corresponding with this glutinous matter, while they exclude every fluid of a different quality."* When confined in an open glass vessel, the goat-moth caterpillar will effect its escape by constructing a curious silken ladder, as represented by Roesel.

Caterpillars, as they increase in size, cast their skins as lobsters do their shells, and emerge into renewed activity under an enlarged covering. Previous to this change, when the skin begins to gird and pinch them, they may be observed to become languid, and indifferent to their food, and at length they cease to eat, and await

* Spectacle de la Nature, vol. i.

the sloughing of their skin. It is now that the faculty of spinning silk seems to be of great advantage to them; for being rendered inactive and helpless by the tightening of the old skin around their expanding body, they might be swept away by the first puff of wind, and made prey of by ground beetles or other carnivorous prowlers. To guard against such accidents, as soon as they feel that they can swallow no more food, from being half choked by the old skin, they take care to secure themselves from danger by moorings of silk spun upon the leaf or the branch where they may be reposing. The caterpillar of the white satin-moth (*Leucoma salicis*, STEPHENS) in this way draws together with silk one or two leaves, similar to the leaf-rollers (*Tortricidæ*), though it always feeds openly without any covering. The caterpillar of the puss-moth again, which, in its third skin, is large and heavy, spins a thick web on the upper surface of a leaf, to which it adheres till the change is effected.

The most important operation, however, of silk-spinning is performed before the caterpillar is transformed into a chrysalis, and is most remarkable in the caterpillars of moths and other four-winged flies, with the exception of those of butterflies; for though these exhibit, perhaps, greater ingenuity, they seldom spin more than a few threads to secure the chrysalis from falling, whereas the others spin for it a complete envelope or shroud. We have already seen, in the preceding pages, several striking instances of this operation, when, probably for the purpose of husbanding a scanty supply of silk, extraneous substances are worked into the texture. In the case of other caterpillars, silk is the only material employed. Of this the cocoon of the silk-worm is the most prominent example, in consequence of its importance in our manufactures and commerce, and on that account will demand from us somewhat minute details, though it would require volumes to incorporate all the information which has been published on the subject.

Silk-Worm.

The silk-worm, like most other caterpillars, changes its skin four times during its growth. The intervals at which the four moultings follow each other depend much on climate or temperature, as well as on the quality and quantity of food. It is thence found, that if they are exposed to a high temperature, say from 81° to 100° Fahrenheit, the moultings will be hastened; and only five days will be consumed in moulting the third or fourth time, whilst those worms that have not been hastened take seven or eight days.*

The period of the moultings is also influenced by the temperature in which the eggs have been kept during the winter. When the heat of the apartment has been regulated, the first moulting takes place on the fourth or fifth day after hatching, the second begins on the eighth day, the third takes up the thirteenth and fourteenth days, and the last occurs on the twenty-second and twenty-third days. The fifth age, in such cases, lasts ten days, at the end of which, or thirty-two days after hatching, the caterpillars attain their full growth, and ought to be three inches in length; but if they have not been properly fed, they will not be so long.

With the age of the caterpillar, its appetite increases, and is at its maximum after the fourth moulting, when it also attains its greatest size. The silk gum is then elaborated in the reservoirs, while the caterpillar ceases to eat, and soon diminishes again in size and weight. This usually requires a period of nine or ten days, commencing from the fourth moulting, after which it begins to spin its shroud of silk. In this operation it proceeds with the greatest caution, looking carefully for a spot in which it may be most secure from interruption.

"We usually," says the Abbé de la Pluche, "give it some little stalks of broom, heath, or a piece of paper rolled up, into which it retires, and begins to move its head to different places, in order to fasten its thread on

* Cours d'Agriculture, par M. Rozier. Paris, 1801.

every side. All this work, though it looks to a bystander like confusion, is not without design. The caterpillar neither arranges its threads nor disposes one over another, but contents itself with distending a sort of cotton or floss to keep off the rain; for Nature having ordained silk-worms to work under trees, they never change their method, even when they are reared in our houses.

"When my curiosity led me to know how they spun and placed their beautiful silk, I took one of them, and frequently removed the floss with which it first attempted to make itself a covering; and as by this means I weakened it exceedingly, when it at last became tired of beginning anew, it fastened its threads on the first thing it encountered, and began to spin very regularly in my presence, bending its head up and down, and crossing to every side. It soon confined its movements to a very contracted space, and, by degrees, entirely surrounded itself with silk; and the remainder of its operations became invisible, though these may be understood from examining the work after it is finished. In order to complete the structure, it must draw out of the gum-bag a more delicate silk, and then with a stronger gum bind all the inner threads over one another.

"Here, then, are three coverings entirely different, which afford a succession of shelter. The outer loose silk, or floss, is for keeping off the rain; the fine silk in the middle prevents the wind from causing injury; and the glued silk, which composes the tapestry of the chamber where the insect lodges, repels both air and water, and prevents the intrusion of cold.

"After building her cocoon, she divests herself of her fourth skin, and is transformed into a chrysalis, and subsequently into a moth (*Bombyx mori*), when, without saw or centre-bit, she makes her way through the shell, the silk, and the floss; for the Being who teaches her how to build herself a place of rest, where the delicate limbs of the moth may be formed without interruption, instructs her likewise how to open a passage for escape.

"The cocoon is like a pigeon's egg, and more pointed

at one end than the other; and it is remarkable that the caterpillar does not interweave its silk towards the pointed end, nor apply its glue there as it does in every other part,* by bending itself all around with great pliantness and agility: what is more, she never fails, when her labour is finished, to fix her head opposite to the pointed extremity. The reason of her taking this position is, that she has purposely left this part less strongly cemented, and less exactly closed. She is instinctively conscious that this is to be the passage for the perfect insect which she carries in her bowels, and has therefore the additional precaution never to place this pointed extremity against any substance that might obstruct the moth at the period of its egress.

"When the caterpillar has exhausted herself to furnish the labour and materials of the three coverings, she loses the form of a worm, her spoils drop all around the chrysalis; first throwing off her skin, with the head and jaws attached to it, and the new skin hardening into a sort of leathery consistence. Its nourishment is already in its stomach, and consists of a yellowish mucus, but gradually the rudiments of the moth unfold themselves,—the wings, the antennæ, and the legs becoming solid. In about a fortnight or three weeks, a slight swelling in the chrysalis may be remarked, which at length produces a rupture in the membrane that covers it, and by repeated efforts the moth bursts through the leathery envelope into the chamber of the cocoon.

"The moth then extends her antennæ, together with her head and feet, towards the point of the cone, which not being thickly closed up in that part gradually yields to her efforts; she enlarges the opening, and at last comes forth, leaving at the bottom of the cone the ruins of its former state—namely, the head and entire skin of the caterpillar, which bear some resemblance to a heap of foul linen."†

Réaumur was of opinion that the moth makes use of

* This is denied by recent observers.

† Spectacle de la Nature, vol. i.

its eyes as a file, in order to effect its passage through the silk; while Malpighi, Peck, and others, believe that it is assisted by an acid which it discharges in order to dissolve the gum that holds the fibres of the silk together (see p. 184). Mr. Swayne denies that the threads are broken at all, either by filing or solution; for he succeeded in unwinding a whole cocoon from which the moth had escaped. The soiling of the cocoon by a fluid, however, we may remark, is no proof of the acid; for all moths and butterflies discharge a fluid when they assume wings, whether they be inclosed in a cocoon or not; but it gives no little plausibility to the opinion, that "the end of the cocoon is observed to be wetted for an hour, and sometimes several hours, before the moth makes its way out."* Other insects employ different *contrivances for escape, as we have already seen, and shall still further exemplify.*

It is the middle portion of the cocoon, after removing the floss or loose silk on the exterior, which is used in our manufactures; and the first preparation is to throw the cocoons into warm water, and to stir them about with twigs, to dissolve any slight gummy adhesions which may have occurred when the caterpillar was spinning. The threads of several cones, according to the strength of the silk wanted, are then taken and wound off upon a reel. The refuse, consisting of what we may call the tops and bottoms of the cones, are not wound, but carded, like wool or cotton, in order to form coarser fabrics. We learn from the fact of the cocoons being generally unwound without breaking the thread, that the insect spins the whole without interruption. It is popularly supposed, however, that if it be disturbed during the operation by any sort of noise, it will take alarm, and break its thread; but Latreille says this is a vulgar error.†

* Count Dandolo's Art of Rearing Silk-Worms, Eng. Transl., p. 215.

† On a tort de croire que le bruit nuise à ces insectes. Hist. Nat. Générale, vol. xiii. p. 170.

The length of the unbroken thread in a cocoon varies from six hundred to a thousand feet; and as it is all spun double by the insect, it will amount to nearly two thousand feet of silk, the whole of which does not weigh above three grains and a half: five pounds of silk from ten thousand cocoons is considerably above the usual average. When we consider, therefore, the enormous quantity of silk which is used at present, the number of worms employed in producing it will almost exceed our comprehension. The manufacture of the silk, indeed, gives employment, and furnishes subsistence, to several millions of human beings; and we may venture to say, that there is scarcely an individual in the civilized world who has not some article made of silk in his possession.

In ancient times, the manufacture of silk was confined to the East Indies and China, where the insects that produce it are indigenous. It was thence brought to Europe in small quantities, and in early times sold at so extravagant a price, that it was deemed too expensive even for royalty. The Emperor Aurelian assigned the expense as a reason for refusing his empress a robe of silk; and our own James I., before his accession to the crown of England, had to borrow of the Earl of Mar a pair of silk stockings to appear in before the English ambassador, a circumstance which probably led him to promote the cultivation of silk in England.* The Roman authors were altogether ignorant of its origin,—some supposing it to be grown on trees as hair grows on animals,—others that it was produced by a shell-fish similar to the mussel, which is known to throw out threads for the purpose of attaching itself to rocks,—others that it was the entrails of a sort of spider, which was fed for four years with paste, and then with the leaves of the green willow, till it burst with fat,—and others that it was the produce of a worm which built nests of clay and collected wax. The insect was at length spread into Persia; and eggs were afterwards, at

the instance of the Emperor Justinian, concealed in hollow canes by two monks, and conveyed to the isle of Cos. This emperor, in the sixth century, caused them to be introduced into Constantinople, and made an object of public utility. They were thence successively cultivated in Greece, in Arabia, in Spain, in Italy, in France, and in all places where any hope could be indulged of their succeeding. In America the culture of the silk-worm was introduced into Virginia in the time of James I., who himself composed a book of instructions on the subject, and caused mulberry-trees and silk-worms' eggs to be sent to the colony. In Georgia, also, lands were granted on condition of planting one hundred white mulberry-trees on every ten acres of cleared land.*

The growth of the silk-worm has also been tried, but with no great success, in this country. Evelyn computed that one mulberry-tree would feed as many silk-worms annually as would produce seven pounds of silk. "According to that estimate," says Barham,† "the two thousand trees already planted in Chelsea Park (which take up one-third of it) will make 14,000 lbs. weight of silk; to be commonly worth but twenty shillings a pound, those trees must make 14,000*l.* per annum." During the last century, some French refugees in the south of Ireland made considerable plantations of the mulberry, and had begun the cultivation of silk with every appearance of success; but since their removal the trees have been cut down.‡ In the vicinity of London, also, a considerable plantation of mulberry-trees was purchased by the British, Irish, and Colonial Silk Company in 1825; but we have not learned whether this Company have any active measures now in operation.

The manufacture of silk was introduced into this country in 1718, at Derby, by Mr. John Lombe, who travelled into Italy to obtain the requisite information; but so jealous were the Italians of this, that according

* North American Review, Oct. 1828, p. 449.

† Essay on the Silk-Worm, p. 95. London, 1719.

‡ Preface to Dandolo on the Silk-Worm, Eng. Transl., p. xiii.

to some statements which have obtained belief, he fell a victim to their revenge, having been poisoned at the early age of twenty-nine.*

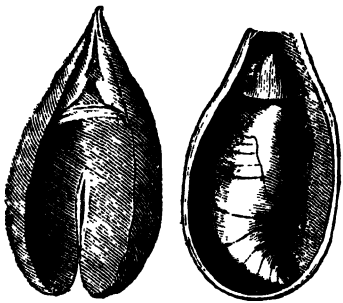
There are not only several varieties of the common silk-worm (*Bombyx mori*), but other species of caterpillars, which spin silk capable of being manufactured, though not of so good qualities as the common silk. None of our European insects, however, seem to be well fitted for the purpose, though it has been proposed by Fabricius and others to try the crimson under-wing (*Catocala sponsa*, SCHRANK), &c. M. Latreille quotes from the 'Recreations of Natural History,' by Wilhelm, the statement that the cocoons of the emperor-moth (*Saturnia pavonia*) had been successfully tried in Germany, by M. Wentzel Hegeer de Berchtoldsdorf, under an imperial patent.

EMPEROR-MOTH.

The emperor-moth, indeed, is no less worthy of our attention with respect to the ingenuity of its architecture than the beauty of its colours, and has consequently attracted the attention of every Entomologist. The caterpillar feeds on fruit-trees and on the willow, and spins a cocoon, in form of a Florence flask, of strong silk, so thickly woven that it appears almost like damask or leather. It differs from most other cocoons in not being closed at the upper or smaller end, which terminates in a narrow circular aperture, formed by the convergence of little bundles of silk, gummed together, and almost as elastic as whalebone. In consequence of all these terminating in needle-shaped points, the entrance of depredators is guarded against, upon the principle which prevents the escape of a mouse from a wire trap. The insect, however, not contented with this protection, constructs another in form of a canopy or dome, within the external aperture, so as effectually to shield the chrysalis from danger. We have formerly remarked (page 181)

* Glover's Directory of the County of Derby, Introd., p. xvi.

that the caterpillar of the *Ægeria asiliformis* of Stephens in a similar way did not appear to be contented with a covering of thin wood, without an additional bonnet of brown wax. The cocoon of the emperor-moth,



Cocoons of the Emperor-moth, cut open to show their structure.

though thus in some measure impenetrable from without, is readily opened from within; and when the moth issues from its pupa case, it easily makes its way out without either the acid or eye-files ascribed to the silk-worm. The elastic silk gives way upon being pushed from within, and when the insect is fairly out, it shuts again of its own accord, like a door with spring hinges,—a circumstance which at first puzzled Roesel not a little when he saw a fine large moth in his box, and the cocoon apparently in the same state as when he had put it there. Another naturalist conjectures that the converging threads are intended to compress the body of the moth as it emerges, in order to force the fluids into the nervures of the wings; for when he took the chrysalis previously out of the cocoon, the wings of the moth never expanded properly.* Had he been much conversant with breeding insects, he would rather,

* Meinecken, quoted by Kirby and Spence, iii. 280.

we think, have imputed this to some injury which the chrysalis had received. We have witnessed the shriveling of the wings which he alludes to, in many instances, and not unfrequently in butterflies which spin no cocoon. The shriveling, indeed, frequently arises from the want of a sufficient supply of food to the caterpillar in its last stage, occasioning a deficiency in the fluids.

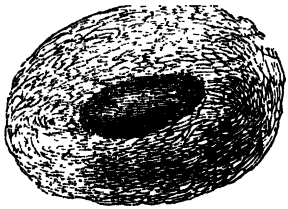
The elasticity of the cocoon is not peculiar to the emperor-moth. A much smaller insect, the green cream-border-moth (*Tortrix chlorana*) before mentioned (page 163), for its ingenuity in bundling up the expanding leaves of the willow, also spins an elastic shroud for its chrysalis, of the singular shape of a boat with the keel uppermost. Like the caterpillar of *Pyralis strigulalis* (page 187), whose building, though of different materials, is exactly of the same form,—it first spins two approximating walls of whitish silk, of the form required, and when these are completed, it draws them forcibly together with elastic threads, so placed as to retain them closely shut. The passage of the moth out of this cocoon might have struck Roesel as still more marvellous than that of his emperor, in which there was at least a small opening; while in the boat cocoon there is none. We have now before us two of these, which we watched the caterpillars through the process of building, in the summer of 1828, and from one only a moth issued,—the other, as often happens, having died in the chrysalis. But what is most remarkable, it is impossible by the naked eye to tell which of these two has been opened by the moth, so neatly has the joining been finished. (J. R.)

Some species of moths spin a very slight silken tissue for their cocoons, being apparently intended more to retain them from falling than to afford protection from other accidents. The gipsy-moth (*Hypogymna dispar*), rare in most parts of Britain, is one of these. It selects for its retreat a crack in the bark of the tree upon which it feeds, and over this spins only a few straggling threads. We found last summer (1829), in the hole of an elm-tree in the Park at Brussels, a group of half a dozen of

these, that did not seem to have spun any covering at all, but trusted to a curtain of moss (*Hypna*) which margined the entrance. (J. R.) In a species nearly allied to this, the yellow-tussock (*Dasychira pudibunda*, STEPHENS), the cocoon, one of which we have now before us, is of a pretty close texture, and interwoven with the long hairs of the caterpillar itself (see figure *b*, page 22), which it plucks out piece-meal during the process of building,—as is also done by the vapourer (*Orgyia antiqua*, HUBNER), and many others.

These are additional instances of the remarks we formerly made, that caterpillars which spin a slight web are transformed into perfect insects in a much shorter period than those which spin more substantial ones. Thus the cream-spot tiger (*Arctia villica*, STEPHENS) lies in chrysalis only three weeks, and therefore does not require a strong web. It is figured below, along with another, which is still slighter, though more ingeniously woven, being regularly meshed like net-work.

A very prettily-netted cocoon is constructed by the



Cocoon of Arctia villica.

Net-work cocoon.

grub of a very small grey weevil (*Hypera Rumicis*), which is not uncommon in July, on the seed spikes of docks (*Rumices*). This cocoon is globular, and not larger than a garden pea, though it appears to be very large in proportion to the pupa of the insect, reminding us not a little of the carved ivory balls from China. The meshes of the net-work are also large, but the materials are strong and of a waxy consistence. Upon remarking that no netting was ever spun over the part of the plant to which the cocoon was attached, we endeavoured to make them spin cocoons perfectly globular, by detaching them when nearly finished; but though we tried four or five in this way, we could not make them add a single mesh after removal, all of them making their escape through the opening, and refusing to re-enter in order to complete their structure. (J. R.)

The silk, if it may be so termed, spun by many species of larvæ is of a still stronger texture than the waxy silk of the little weevil just mentioned. We recently met with a remarkable instance of this at Lee, in the cocoons of one of the larger ichneumons (*Ophion Vinulæ?* STEPHENS), inclosed in that of a puss-moth (*Cerura Vinula*)—itself remarkable for being composed of sand as well as wood, the fibres of which had been scooped out of the under-ground cross-bar of an old paling, to which it was attached. But the most singular portion of this was the junction of the outer wall with the edges of the hollow thus scooped out, which was formed of fibres of wood placed across the fibres of the bar nearly at right angles, and strongly cemented together, as if to form a secure foundation for the building.

In this nest were formed, surreptitiously introduced into the original building, five empty cells of a black colour, about an inch long, and a sixth of an inch in diameter; nearly cylindrical in form, but somewhat flattened; vertical and parallel to one another, though slightly curved on the inner side. The cells are composed of strong and somewhat coarse fibres, more like the carbonized rootlets of a tree than silk, and resembling in texture a piece of coarse milled cloth or felt, such as is

Nest of Puss-moth, inclosing five cocoons of an Ichneumon. Natural size.

used for the bases of plated hats. It is worthy of remark, that all these cells opened towards one end, as if the caterpillars which constructed them had been aware that the wall of the puss-moth, in which the flies would have to make a breach, was very hard, and would require their united efforts to effect an escape. The importance of such a precaution will appear more strikingly, when we compare it with the instance formerly mentioned (page 185), in which only one ichneumon had been able to force its way out. (J. R.)

It appears indispensable to some grubs to be confined within a certain space in order to construct their cocoons. We saw this well exemplified in the instance of a grub of one of the mason-bees (*Osmia bicornis*), which we took from its nest, and put into a box, with the pollen paste which the mother bee had provided for its subsistence. (See pages 43, 44.) When it had completed its growth, it began to spin, but in a very awkward manner —attaching threads, as if at random, to the bits of pollen which remained undevoured, and afterwards tumbling about to another part of the box, as if dissatisfied with what it had done. It sometimes persevered to spin in one place till it had formed a little vaulted wall; but it

abandoned at the least three or four of these in order to begin others, till at length, as if compelled by the extreme urgency of the stimulus of its approaching change, it completed a shell of shining brown silk, woven into a close texture. Had the grub remained within the narrow clay cell built for it by the mother bee, it would, in all probability, not have thus exhausted itself in vain efforts at building, which were likely to prevent it from ever arriving at the perfect state—a circumstance which often happens in the artificial breeding of insects. This bee, however, made its appearance the following spring. (J. R.)

Beside silk, the cocoons of many insects are composed of other animal secretions, intended to strengthen or otherwise perfect their texture. We have already seen that some caterpillars pluck off their own hair to interweave amongst their silk; there are others which produce a peculiar substance for the same purpose. The lackey caterpillar (*Clisiocampa neustria*, CURTIS) in this manner lines its cocoon with pellets of a downy substance, resembling little tufts of the flowers of sulphur. The small egger, again (*Eriogaster lanestris*, GERMAR), can scarcely be said to employ silk at all,—the cocoon being of a uniform texture, looking, at first sight, like dingy Paris plaster, or the shell of a pheasant's egg; but upon being broken, and inspected narrowly, a few threads of silk may be seen interspersed through the whole. In size it is not larger than the egg of the gold-crested wren. It has been considered by Brahm a puzzling circumstance, that this cocoon is usually perforated with one or two little holes, as if made by a pin from without; and Kirby and Spence tell us that their use has not been ascertained.* May they not be left as air-holes for the included chrysalis, as the close texture of the cocoon might, without this provision, prove fatal to the animal? Yet, on comparing one of these with a similar cocoon of the large egger-moth (*Lasiocampa Quercus*), we find no air-holes in the latter, as we might have been led to

* Brahm's Ins. Nat. 289, and Kirby and Spence's Intr. iii. 223.

expect from the closeness of its texture. We found a cocoon of a saw-fly (*Trichiosoma*), about the same size as that of the egger, attached to a hawthorn twig, in a hedge at New-Cross, Deptford, but of a leathery texture, and, externally, exactly the colour of the bark of the tree. During the summer of 1830 we found a considerable number of the same cocoons. These were all without air-holes. The egger, we may remark, unlike the dock-weevil or the bee-grub just mentioned, can work her cocoon without any point of attachment. We had a colony of these caterpillars in the summer of 1825, brought from Epping Forest, and saw several of them work their cocoons, and we could not but admire the dexterity with which they avoided filling up the little pin-holes. The supply of their building material was evidently measured out to them in the exact quantity required; for when we broke down a portion of their wall, by way of experiment, they did not make it above half the thickness of the previous portion, though they plainly preferred having a thin wall to leaving the breach unclosed. (J. R.)

Several species of caterpillars, that spin only silk, are social, like some of those we formerly mentioned, which unite to form a common tent of leaves (see pages 165, 166). The most common instance of this is in the caterpillars which feed on the nettle—the small tortoise-shell (*Vanessa urticæ*), and the peacock's eye (*V. I*). Colonies of these may be seen, after Midsummer, on almost every clump of nettles, inhabiting a thin web of an irregular oval shape, from which they issue out to feed on the leaves, always returning when their appetite is satisfied, to assist their companions in extending their premises. Other examples, still more conspicuous from being seen on fruit-trees and in hedges, occur in the caterpillars of the small ermine-moth (*Yponomeuta padella*), and of the lackey (*Clisiocampa neustria*), which in some years are but too abundant, though in others they are seldom met with. In the summer of 1826, every hedge and fruit-tree around London swarmed with colonies of the ermine, though it has not since been

plentiful; and in the same way, during the summer of 1829, the lackeys were to be seen every where. We mention this irregularity of appearance that our readers may not disappoint themselves by looking for what is not always to be found. It is probable, that in 1830, the lackeys will be few, for, notwithstanding the myriads of caterpillars last summer, we saw only a single moth of this species, and out of a number of chrysalides which a young friend had in his nurse-boxes, not one moth was bred.

The caterpillars of other moths, which are in some years very common—such as the brown-tail (*Porthesia auriflua*), and the golden-tail (*P. Chrysorrhœa*), are also social; and, as the eggs are hatched late in the summer, the brood passes the winter in a very closely woven nest of warm silk. This is usually represented as composed of leaves which have had their pulpy parts

Winter nest of the Social Caterpillars of the Brown-tail Moth. (*Porthesia auriflua*), figured from specimen.

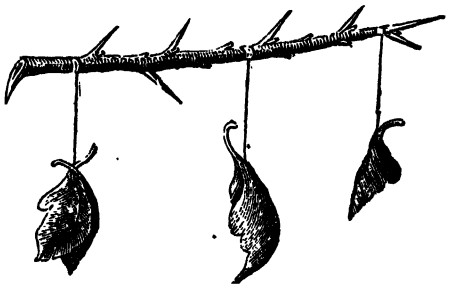
eaten as food by the colonists; but from minute observation of at least twenty of these nests in the winter of 1828-9, we are quite satisfied that leaves are only an accidental, and not a necessary, part of the structure. When a leaf happens to be in the line of the walls of the nest, it is included; but there is no apparent design in pressing it into the service, nor is a branch selected because it is leafy. On the contrary, by far the greater number of these nests do not contain a single leaf, but are composed entirely of grey silk. In external form, no two of these nests are alike; as it depends entirely upon the form of the branch. When, therefore, there is only one twig, it is somewhat egg-shaped; but when there are several twigs, it commonly joins each, assuming an angular shape, as may be seen in the preceding figure.

This irregularity arises from the circumstance of each individual acting on its own account, without the direc-

Winter nests of *Porthesia chrysorrhœa*, one being cut open to show the chambers. The dots represent the egesta of the caterpillars.

tion or superintendence of the others. The interior of the structure is, for the same reason, more regular, being divided into compartments, each of which forms a chamber for one or more individuals. Previous to the cold weather, these chambers have but slight partitions; but before the frosts set in the whole is made thick and warm.

A no less remarkable winter nest, of a small species of social caterpillar, is described by M. Bonnet, which we omitted to introduce when treating of the Glanville fritillary (page 164). The nest in question is literally pendulous, being hung from the branch of a fruit-tree by a strong silken thread. It consists of one or two leaves neatly folded, and held together with silk, in which the caterpillars live harmoniously together.



Pendulous leaf-nests, from Bonnet.

In a recently published volume of 'Travels in Mexico,' we find a very remarkable account of some pendulous nests of caterpillars, which appear to be almost as curious as the nests of the pasteboard-making wasps, described at p. 87. The author of these Travels does not define the species of caterpillar whose constructions attracted his observation. He says, "After having ascended for about an hour, we came to the region of oaks and other majestically tall trees, the names of which I

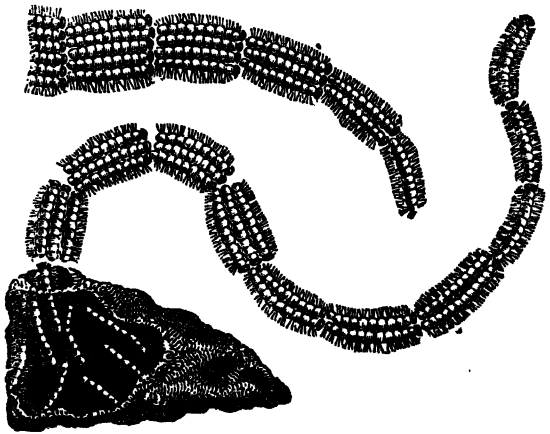
could not learn. Suspended from their stately branches, were innumerable nests, enclosed, apparently, in white paper bags, in the manner of bunches of grapes in England, to preserve them from birds and flies. I had the curiosity to examine one of them, which I found to contain numberless caterpillars. The texture is so strong that it is not easily torn; and the interior contained a quantity of green leaves, to support the numerous progeny within." *

In all the nests of social caterpillars, care is taken to leave apertures for passing out and in. It is remarkable, also, that however far they may ramble from their nest, they never fail to find their way back when a shower of rain or nightfall renders shelter necessary. It requires no great shrewdness to discover how they effect this; for by looking closely at their track it will be found that it is carpeted with silk—no individual moving an inch without constructing such a pathway, both for the use of his companions and to facilitate his own return. All these social caterpillars, therefore, move more or less in processional order, each following the road which the first chance traveller has marked out with his strip of silk carpeting.

There are some species, however, which are more remarkable than others in the regularity of their processional marchings, particularly two which are found in the south of Europe, but are not indigenous in Britain. The one named by Réaumur the processionary (*Cnethocampa processionea*, STEPHENS) feeds upon the oak; a brood dividing, when newly hatched, into one or more parties of several hundred individuals, which afterwards unite in constructing a common nest nearly two feet long, and from four to six inches in diameter. As it is not divided like that of the brown-tails into chambers, but consists of one large hall, it is not necessary that there should be more openings than one; and accordingly, when an individual goes out and carpets a path, the whole colony instinctively follow in the same track,

* Hardy's Travels in the Interior of Mexico, p. 32.

though from the immense population they are often compelled to march in parallel files from two to six deep. The procession is always headed by a single caterpillar; sometimes the leader is immediately followed by one or two in single file, and sometimes by two abreast, as represented in the cut. A similar procedure is followed by a species of social caterpillars which feed on the pine in Savoy and Languedoc; and though their nests are not half the size of the preceding, they are more worthy of notice, from the strong and excellent quality of their silk, which Réaumur was of opinion might be advantageously manufactured. Their nests consist of more chambers than one, but are furnished with a main entrance, through which the colonists conduct their foraging processions.



Nest and order of marching of the Processionary Caterpillars of the oak (*Cnethocampa processionea*).

CHAPTER XVIII.

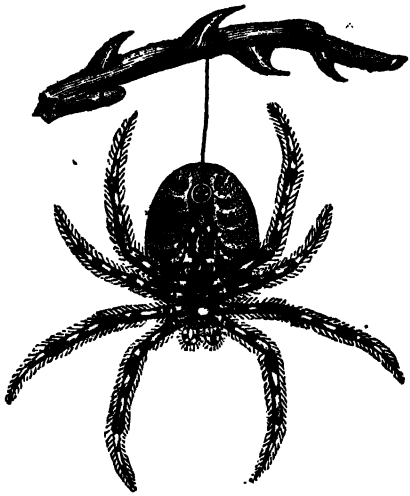
Structures of Spiders.

MODERN naturalists do not rank spiders among insects, because they have no antennæ, and no division between the head and the shoulders. They breathe by leaf-shaped gills, situated under the belly, instead of spiracles in the sides; have a heart connected with these; have eight legs instead of six; and eight fixed eyes. But as spiders are popularly considered insects, it will sufficiently suit our purpose to introduce them here as such.

The apparatus by which spiders construct their ingenious fabrics is much more complicated than that which we have described as common to the various species of caterpillars. Caterpillars have only two reservoirs for the materials of their silk; but spiders, according to the dissections of M. Treviranus, have four principal vessels, two larger and two smaller, with a number of minute ones at their base. Several small tubes branch towards the reservoirs, for carrying to them, no doubt, a supply of the secreted material. Swammerdam describes them as twisted into many coils of an agate colour.* We do not find them coiled, but nearly straight; and of a deep yellow colour. From these, when broken, threads can be drawn out like those spun by the spider, though we cannot draw them so fine by many degrees.

From these little flasks or bags of gum, situated near the apex of the abdomen, and not at the mouth as in caterpillars, a tube originates, and terminates in the external spinnerets, which may be seen by the naked eye in the larger spiders, in the form of five little teats surrounded by a circle, as represented in the following figure.

* Hill's Swammerdam, part i. p. 23.



Garden Spider (*Epeira diadema*), suspended by a thread proceeding from its spinneret.

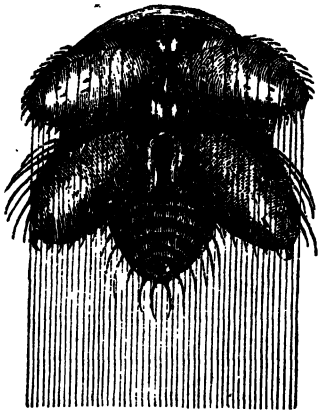
We have seen that the silken thread of a caterpillar is composed of two united within the tube of the spinneret, but the spider's thread would appear, from the first view of its five spinnerets, to be quintuple, and in some species which have six teats, so many times more. It is not safe, however, in our interpretations of nature to proceed upon conjecture, however plausible, nor to take anything for granted which we have not actually seen; since our inferences in such cases are almost certain to be erroneous. If Aristotle, for example, had ever looked narrowly at a spider when spinning, he could not have fancied, as he does, that the materials which it uses are nothing but wool stripped from its body. On looking, then, with a strong magnifying glass, at the teat-shaped

spinnerets of a spider, we perceive them studded with regular rows of minute bristle-like points, about a thousand to each teat, making in all from five to six thousand. These are minute tubes which we may appropriately *term spinnerules, as each is connected with the internal* reservoirs, and emits a thread of inconceivable fineness. In the figure below, this wonderful apparatus is represented as it appears in the microscope.

Spinnerets of a Spider magnified to show the *Spinnerules*.

We do not recollect that naturalists have ventured to assign any cause for this very remarkable multiplicity of the spinnerules of spiders, so different from the simple spinneret of caterpillars. To us it appears to be an admirable provision for their mode of life. Caterpillars neither require such strong materials, nor that their thread should dry as quickly. It is well known in our manufactures, particularly in rope-spinning, that in cords of equal thickness, those which are composed of many smaller ones united are greatly stronger than those which are spun at once. In the instance of the spider's thread, this principle must hold still more strikingly, inasmuch as it is composed of fluid materials that require to be dried rapidly, and this drying must be greatly facilitated

by exposing so many to the air separately before their union, which is effected at the distance of about a tenth of an inch from the spinnerets. In the following figure *each of the threads represented is reckoned to contain one hundred minute threads, the whole forming only* one of the spider's common threads.



A single thread of a Spider, greatly magnified, so that, for the small space represented, the lines are shown as parallel.

Lecuwenhoeck, in one of his extraordinary microscopical observations on a young spider not bigger than a grain of sand, upon enumerating the threadlets in one of its threads, calculated that it would require four millions of them to be as thick as a hair of his beard.

Another important advantage derived by the spider from the multiplicity of its threadlets is, that the thread affords a much more secure attachment to a wall, a branch of a tree, or any other object, than if it were simple; for, upon pressing the spinneret against the object, as spiders always do when they fix a thread, the spinnerules are extended over an area of some diameter, from every

hair's breadth of which a *strand*, as rope-makers term it, is extended to compound the main cord. The following figure exhibits this ingenious contrivance.

Attached end of a Spider's thread magnified.

Those who may be curious to examine this contrivance, will see it best when the line is attached to any black object, for the threads, being whitish, are, in other cases, not so easily perceived.

Shooting of the Lines.

It has long been considered a curious though a difficult investigation, to determine in what manner spiders, seeing that they are destitute of wings, transport themselves from tree to tree, across brooks, and frequently through the air itself, without any apparent starting point. On looking into the authors who have treated upon this subject, it is surprising how little there is to be met with that is new, even in the most recent. Their conclusions, or rather their conjectural opinions, are, however, worthy of notice; for by unlearning error, we the more firmly establish truth.

1. One of the earliest notions upon this subject is that of Blancanus, the commentator on Aristotle, which is

partly adopted by Redi, by Henricus Regius of Utrecht, by Swammerdam,* by Lehmann, and by Kirby and Spence.† "The spider's thread," says Swammerdam, "is generally made up of two or more parts, and after descending by such a thread, it ascends by one only, and is thus enabled to waft itself from one height or tree to another, even across running waters; the thread it leaves loose behind it being driven about by the wind, and so fixed to some other body." "I placed," says Kirby, "the large garden spider (*Epeira diadema*) upon a stick about a foot long, set upright in a vessel containing water. . . . . It let itself drop, not by a single thread, but by *two*, each distant from the other about the twelfth of an inch, guided, as usual, by one of its hind feet, and one apparently smaller than the other. When it had suffered itself to descend nearly to the surface of the water, it stopped short, and by some means, which I could not distinctly see, broke off, close to the spinners, the smallest thread, which still adhering by the other end to the top of the stick, floated in the air, and was so light as to be carried about by the slightest breath. On approaching a pencil to the loose end of this line, it did not adhere from mere contact. I, therefore, twisted it once or twice round the pencil, and then drew it tight. The spider, which had previously climbed to the top of the stick, immediately pulled at it with one of its feet, and finding it sufficiently tense, crept along it, strengthening it as it proceeded by another thread, and thus reached the pencil."

We have repeatedly witnessed this occurrence, both in the fields and when spiders were placed for experiment, as Kirby has described; but we very much doubt that the thread broken is ever intended as a bridge cable, or that it would have been so used in that instance, had it not been artificially fixed and accidentally found again by the spider. According to our observations, a spider never abandons, for an instant, the thread which she dispatches in quest of an attachment, but uniformly keeps

* Swammerdam, part i. p. 24. † Intr. vol. i. p. 415.

trying it with her feet, in order to ascertain its success. We are, therefore, persuaded, that when a thread is broken in the manner above described, it is because it has been spun too weak, and spiders may often be seen breaking such threads in the process of netting their webs. (J. R.)

The plan, besides, as explained by these distinguished writers, would more frequently prove abortive than successful, from the cut thread not being sufficiently long. They admit, indeed, that spiders' lines are often found "a yard or two long, fastened to twigs of grass not a foot in height. . . . . Here, therefore, some other process must have been used."*

2. Our celebrated English naturalist, Dr. Lister, whose treatise upon our native spiders has been the basis of every subsequent work on the subject, maintains that "some spiders shoot out their threads in the same manner that porcupines do their quills;† that whereas the quills of the latter are entirely separated from their bodies, when thus shot out, the threads of the former remain fixed to their anus, as the sun's rays to its body."‡ A French periodical writer goes a little farther, and says, that spiders have the power of shooting out threads, and directing them at pleasure towards a determined point, judging of the distance and position of the object by some sense of which we are ignorant.§ Kirby also says, that he once observed a small garden spider (*Aranea reticulata*) "standing midway on a long perpendicular fixed thread, and an appearance caught" his "eye, of what seemed to be the emission of threads." "I," therefore, he adds, "moved my arm in the direction in which they apparently proceeded, and, as I had suspected, a floating thread attached itself to my coat, along which the spider crept. As this was connected with the spinners of the spider, it could not have been

* Kirby and Spence, vol. i. Intr. p. 416.

† Porcupines do not shoot out their quills, as was once generally believed.

‡ Lister, Hist. Animalia Angliæ, 4to. p. 7.

§ Phil. Mag. ii. p. 275.

formed" by breaking a "secondary thread."* Again, in speaking of the gossamer-spider, he says, "it first extends its thigh, shank, and foot, into a right line, and then, elevating its abdomen till it becomes vertical, *shoots its thread* into the air, and flies off from its station."†

Another distinguished naturalist, Mr. White of Selborne, in speaking of the gossamer-spider, says, "Every day in fine weather in autumn do I see these spiders shooting out their webs, and mounting aloft: they will go off from the finger, if you will take them into your hand. Last summer, one alighted on my book as I was reading in the parlour; and running to the top of the page, and *shooting out a web*, took its departure from thence. But what I most wondered at was, that it went off with considerable velocity in a place where no air was stirring; and I am sure I did not assist it with my breath."‡

Having so often witnessed the thread set afloat in the air by spiders, we can readily conceive the way in which those eminent naturalists were led to suppose it to be ejected by some animal force acting like a syringe; but as the statement can be completely disproved by experiment, we shall only at present ask, in the words of Swammerdam—"how can it be possible that a thread so fine and slender should be shot out with force enough to divide and pass through the air?—is it not rather probable that the air would stop its progress, and so entangle it and fit it to perplex the spider's operations?"§ The opinion, indeed, is equally improbable with another, suggested by Dr. Lister, that the spider can retract her thread within the abdomen, after it has been emitted.‖ De Geer¶ very justly joins Swammerdam in rejecting both of these fancies, which, in our own earlier observations upon spiders, certainly struck us as plausible and

* Vol. i. Intr. p. 417. † Ibid. ii. p. 339.
‡ Nat. Hist. of Selborne, vol. i. p. 327.
§ Book of Nature, part i. p. 25.
‖ Hist. Anim. Angliæ, 4to. ¶ Mémoires, vol. vii. p. 189.

true. There can be no doubt, indeed, that the animal has a voluntary power of permitting the material to escape, or stopping it at pleasure, but this power is not projectile.

3. "There are many people," says the Abbé de la Pluche, "who believe that the spider flies when they see her pass from branch to branch, and even from one high tree to another; but she transports herself in this manner: she places herself upon the end of a branch, or some projecting body, and there fastens her thread; after which, with her two hind feet, she squeezes her dugs (*spinnerets*), and presses out one or more threads of two or three ells in length, which she leaves to float in the air till it be fixed to some particular place."* Without pretending to have observed this, Swammerdam says, "I can easily comprehend how spiders, without giving themselves any motion, may, by only compressing their spinnerets, force out a thread, which being driven by the wind, may serve to waft them from one place to another."† Others, proceeding upon a similar notion, give a rather different account of the matter. "The spider," says Bingley, "fixes one end of a thread to the place where she stands, and then with her hind paws *draws out* several other threads from the nipples, which, being lengthened out and driven by the wind to some neighbouring tree or other object, are by their natural clamminess fixed to it."‡

Observation gives some plausibility to the latter opinion, as the spider always actively uses her legs, though not to draw out the thread, but to ascertain whether it has caught upon any object. The notion of her pressing the spinneret with her feet must be a mere fancy; at least it is not countenanced by anything which we have observed.

4. An opinion much more recondite is mentioned, if it was not started, by M. D'Isjonval, that the floating of the spider's thread is electrical. "Frogs, cats, and other

* Spectacle de la Nature, vol. i. † Book of Nature, pt. i. p. 25.
‡ Animal Biography, vol. iii. p. 475, 3rd edition.

animals," he says, "*are affected by natural electricity,* and feel the change of weather; but no other animal more than myself and my spiders." During wet and windy weather he accordingly found that they spun very short lines, "but when a spider spins a long thread, there is a certainty of fine weather for at least ten or twelve days afterwards."* A periodical writer, who signs himself Carolan,† fancies that in darting out her thread the spider emits a stream of air, or some subtle electric fluid, by which she guides it as if by magic.

A living writer (Mr. John Murray) whose learning and skill in conducting experiments give no little weight to his opinions, has carried these views considerably farther. "The aëronautic spider," he says, "can propel its thread both horizontally and vertically, and at all relative angles, in motionless air, and in an atmosphere agitated by winds; nay more, the aërial traveller can even dart its thread, to use a nautical phrase, in the 'wind's eye.' My opinion and observations are based on many hundred experiments. . . . . The entire phenomena are electrical. When a thread is propelled in a vertical plane, it remains perpendicular to the horizontal plane, always upright, and when others are projected at angles more or less inclined, their direction is invariably preserved; the threads never intermingle, and when a pencil of threads is propelled, it ever presents the appearance of a divergent brush. These are electrical phenomena, and cannot be explained but on electrical principles."

"In clear, fine weather, the air is invariably positive; and it is precisely in such weather that the aëronautic spider makes its ascent most easily and rapidly, whether it be in summer or in winter." "When the air is weakly positive, the ascent of the spider will be difficult, and its altitude extremely limited, and the threads propelled will be but little elevated above the horizontal plane. When negative electricity prevails, as in cloudy

* Brez, Flore des Insectophiles. Notes, Supp. p. 134.
† Thomson's Ann. of Philosophy, vol. iii. p. 306.

weather, or on the approach of rain, and the index of De Saussure's hygrometer rapidly advancing towards humidity, the spider is unable to ascend."*

Mr. Murray had previously told us, that "when a stick of excited sealing-wax is brought near the thread of suspension, it is evidently repelled; consequently, the electricity of the thread is of a negative character," while "an excited glass tube brought near, seemed to attract the thread, and with it the aëronautic spider."† His friend, Mr. Bowman, further describes the aërial spider as "shooting out four or five, often six or eight, extremely fine webs several yards long, which waved in the breeze, diverging from each other like a pencil of rays." One of them "had two distinct and widely diverging fasciculi of webs," and "a line uniting them would have been at right angles to the direction of the breeze."‡

Such is the chief evidence in support of the electrical theory; but though we have tried these experiments, we have not succeeded in verifying any one of them. The following statements of Mr. Blackwall come nearer our own observations.

5. "Having procured a small branched twig," says Mr. Blackwall, "I fixed it upright in an earthen vessel containing water, its base being immersed in the liquid, and upon it I placed several of the spiders which produce gossamer. Whenever the insects thus circumstanced were exposed to a current of air, either naturally or artificially produced, they directly turned the thorax towards the quarter whence it came, even when it was so slight as scarcely to be perceptible, and elevating the abdomen, they emitted from their spinners a small portion of glutinous matter, which was instantly carried out in a line, consisting of four finer ones, with a velocity equal, or nearly so, to that with which the air moved, as was apparent from observations made on the motion of detached lines similarly exposed. The spiders, in the next place,

* Loudon's Mag. of Nat. Hist., vol. i. p. 322.
† Experim. Researches in Nat. Hist., p. 136.
‡ Mag. Nat. Hist. vol. i. p. 324.

carefully ascertained whether their lines had become firmly attached to any object or not, by pulling at them with the first pair of legs; and if the result was satisfactory, after tightening them sufficiently, they made them pass to the twig; then discharging from their spinners, which they applied to the spot where they stood, a little more of their liquid gum, and committing themselves to these bridges of their own constructing, they passed over them in safety, drawing a second line after them, as a security in case the first gave way, and so effected their escape.

"Such was invariably the result when spiders were placed where the air was liable to be sensibly agitated: I resolved, therefore, to put a bell-glass over them; and in this situation they remained seventeen days, evidently unable to produce a single line by which they could quit the branch they occupied, without encountering the water at its base; though, on the removal of the glass, they regained their liberty with as much celerity as in the instances already recorded.

"This experiment, which, from want of due precaution, has misled so many distinguished naturalists, I have tried with several geometric spiders, and always with the same success."*

Mr. Blackwall, from subsequent experiments, says he is "confident in affirming, that in motionless air spiders have not the power of darting their threads even through the space of half an inch."† The following details are given in confirmation of this opinion. Mr. Blackwall observed, the 1st Oct., 1826, a little before noon, with the sun shining brightly, no wind stirring, and the thermometer in the shade ranging from 55°.5 to 64°, a profusion of shining lines crossing each other at every angle, forming a confused net-work, covering the fields and hedges, and thickly coating his feet and ankles, as he walked across a pasture. He was more struck with the phenomenon because on the previous day a strong gale

* Linn. Trans., vol. xv. p. 456.
† Mag. Nat. Hist., vol. ii. p. 397.

of wind had blown from the south, and as gossamer is only seen in calm weather, it must have been all produced within a very short time.

"What more particularly arrested my attention," says Mr. Blackwall, "was the ascent of an amazing quantity of webs, of an irregular, complicated structure, resembling ravelled silk of the finest quality, and clearest white; they were of various shapes and dimensions, some of the largest measuring upwards of a yard in length, and several inches in breadth in the widest part; while others were almost as broad as long, presenting an area of a few square inches only.

"These webs, it was quickly perceived, were not formed in the air, as is generally believed, but at the earth's surface. The lines of which they were composed, being brought into contact by the mechanical action of gentle airs, adhered together, till, by continual additions, they were accumulated into flakes or masses of considerable magnitude, on which the ascending current, occasioned by the rarefaction of the air contiguous to the heated ground, acted with so much force as to separate them from the objects to which they were attached, raising them in the atmosphere to a perpendicular height of at least several hundred feet. I collected a number of these webs about mid-day, as they rose; and again in the afternoon, when the upward current had ceased, and they were falling; but scarcely one in twenty contained a spider: though, on minute inspection, I found small winged insects, chiefly aphides, entangled in most of them.

"From contemplating this unusual display of gossamer, my thoughts were naturally directed to the animals which produced it, and the countless myriads in which they swarmed almost created as much surprise as the singular occupation that engrossed them. Apparently actuated by the same impulse, all were intent upon traversing the regions of air; accordingly, after gaining the summits of various objects, as blades of grass, stubble, rails, gates, &c., by the slow and laborious process of climbing, they raised themselves still higher by straightening their limbs; and elevating the abdomen, by bringing it

from the usual horizontal position into one almost perpendicular, they emitted from their spinning apparatus a small quantity of the glutinous secretion with which they construct their webs. This viscous substance being drawn out by the ascending current of rarefied air into fine lines several feet in length, was carried upward, until the spiders, feeling themselves acted upon with sufficient force in that direction, quitted their hold of the objects on which they stood, and commenced their journey by mounting aloft.

"Whenever the lines became inadequate to the purpose for which they were intended, by adhering to any fixed body, they were immediately detached from the spinners and so converted into terrestrial gossamer, by means of the last pair of legs, and the proceedings just described were repeated; which plainly proves that these operations result from a strong desire felt by the insects to effect an ascent."* Mr. Blackwall has recently read a paper (still unpublished) in the Linnean Society, confirmatory of his opinions.

6. Without going into the particulars of what agrees or disagrees in the above experiments with our own observations, we shall give a brief account of what we have actually seen in our researches. (J. R.) So far as we have determined, then, all the various species of spiders, how different soever the form of their webs may be, proceed in the circumstance of shooting their lines precisely alike; but those which we have found the most manageable in experimenting, are the small gossamer spider (*Aranea obtextrix*, Bechstein), known by its shining blackish-brown body and reddish-brown semi-transparent legs; but particularly the long-bodied spider (*Tetragnatha extensa*, Latr.), which varies in colour from green to brownish or grey—but has always a black line along the belly, with a silvery white or yellowish one on each side. The latter is chiefly recommended by being a very industrious and persevering spinner, while its

* Linn. Trans., vol. xv. p. 453.

movements are easily seen, from the long cylindrical form of its body and the length of its legs.

We placed the above two species with five or six others, including the garden, the domestic, and the labyrinthic spiders, in empty wine-glasses, set in tea-saucers filled with water to prevent their escape. When they discovered, by repeated descents from the brims of the glasses, that they were thus surrounded by a wet ditch, they all set themselves to the task of throwing their silken bridges across. For this purpose they first endeavoured to ascertain in what direction the wind blew, or rather (as the experiment was made in our study) which way any current of air set,—by elevating their arms as we have seen sailors do in a dead calm. But, as it may prove more interesting to keep to one individual, we shall first watch the proceedings of the gossamer spider.

Finding no current of air on any quarter of the brim of the glass, it seemed to give up all hopes of constructing its bridge of escape, and placed itself in the attitude of repose; but no sooner did we produce a stream of air, by blowing gently towards its position, than, fixing a thread to the glass, and laying hold of it with one of its feet, by way of security, it placed its body in a vertical position, with its spinnerets extended outwards; and immediately we had the pleasure of seeing a thread streaming out from them several feet in length, on which the little aëronaut sprung up into the air. We were convinced, from what we thus observed, that it was the double or bend of the thread which was blown into the air; and we assigned as a reason for her previously attaching and drawing out a thread from the glass, the wish to give the wind a *point d'appui*—something upon which it might have a *purchase*, as a mechanic would say of a lever. The bend of the thread, then, on this view of the matter, would be carried out by the wind,—would form the point of impulsion,—and, of course, the escape bridge would be an ordinary line doubled.

Such was our conclusion, which was strongly corro-

borated by what we subsequently found said by M. Latreille—than whom no higher authority could be given. "When the animal," says he, "desires to cross a brook, she fixes to a tree or some other object one of the ends of her first threads, in order that the wind or a current of air may carry the other end beyond the obstacle;"* and as one end is always attached to the spinnerets, he must mean that the double of the thread flies off. In his previous publications, however, Latreille had contented himself with copying the statement of Dr. Lister.

In order to ascertain the fact, and put an end to all doubts, we watched, with great care and minuteness, the proceedings of the long-bodied spider above mentioned, by producing a stream of air in the same manner, as it perambulated the brim of the glass. It immediately, as the other had done, attached a thread and raised its body perpendicularly, like a tumbler standing on his hands with his head downwards; but we looked in vain for this thread bending, as we had at first supposed, and going off double. Instead of this it remained tight, while another thread, or what appeared to be so, streamed off from the spinners, similar to smoke issuing through a pin-hole, sometimes in a line, and sometimes at a considerable angle, with the first, according to the current of the air,—the first thread, extended from the glass to the spinnerets, remaining all the while tight drawn in a right line. It further appeared to us, that the first thread proceeded from the pair of spinnerets nearest the head, while the floating thread came from the outer pair,—though it is possible in such minute objects we may have been deceived. That the first was continuous with the second, without any perceptible joining, we ascertained in numerous instances, by catching the floating line and pulling it tight, in which case the spider glides along without attaching another line to

* ——"L'un des bouts de ces premiers fils, afin que le vent ou un courant d'air pousse l'autre extrémité de l'un d'eux au de là de l'obstacle."—Dict. Classique d'Hist. Nat., vol. i. p. 510.

the glass; but if she have to coil up the floating line to tighten it, as usually happens, she gathers it into a packet and glues the two ends tight together. Her body, while the floating line streamed out, remained quite motionless, but we distinctly saw the spinnerets not only projected, as is always done when a spider spins, but moved in the same way as an infant moves its lips when sucking. We cannot doubt, therefore, that this motion is intended to emit (if *eject* or *project* be deemed too strong words) the liquid material of the thread; at the same time, we are quite certain that it cannot throw out a single inch of thread without the aid of a current of air. A long-bodied spider will thus throw out in succession as many threads as we please, by simply blowing towards it; but not one where there is no current, as under a bell-glass, where it may be kept till it die, without being able to construct a bridge over water of an inch long. We never observed more than one floating thread produced at the same time; though other observers mention several.

The probable commencement, we think, of the floating line, is by the emission of little globules of the glutinous material to the points of the spinnerules—perhaps it may be dropped from them, if not ejected, and the globules being carried off by the current of air, drawn out into a thread. But we give this as only a conjecture, for we could not bring a glass of sufficient power to bear upon the spinnerules at the commencement of the floating line.

In subsequent experiments we found, that it was not indispensable for the spider to rest upon a solid body when producing a line, as she can do so while she is suspended in the air by another line. When the current of air also is strong, she will sometimes commit herself to it by swinging from the end of the line. We have even remarked this when there was scarcely a breath of air.

We tried another experiment. We pressed pretty firmly upon the base of the spinnerets, so as not to injure the spider, blowing obliquely over them; but no floating line appeared. We then touched them with a pencil

and drew out several lines an inch or two in length, upon which we blew in order to extend them, but in this also *we were unsuccessful, as they did not lengthen more* than a quarter of an inch. We next traced out the reservoirs of a garden-spider (*Epeira diadema*), and immediately taking a drop of the matter from one of them on the point of a fine needle, we directed upon it a strong current of air, and succeeded in blowing out a thick yellow line, as we might have done with gum-water, of about an inch and a half long.

When we observed our long-bodied spider eager to throw a line by raising up its body, we brought within three inches of its spinnerets an excited stick of sealing-wax, of which it took no notice, nor did any thread extend to it, not even when brought almost to touch the spinnerets. We had the same want of success with an excited glass rod; and indeed we had not anticipated any other result, as we have never observed that these either attract or repel the floating threads, as Mr. Murray has seen them do; nor have we ever seen the end of a floating thread separated into its component threadlets and diverging like a brush, as he and Mr. Bowman describe. It may be proper to mention that Mr. Murray, in conformity with his theory, explains the shooting of lines in a current of air by the electric state produced by motion in consequence of the mutual friction of the gaseous particles. But this view of the matter does not seem to affect our statements.

Nests, Webs, and Nets of Spiders.

The neatest, though the smallest spider's nest which we have seen, was constructed in the chink of a garden post, which we had cut out the previous summer in getting at the cells of a carpenter-bee. The architect was one of the larger hunting-spiders, erroneously said by some naturalists to be incapable of spinning. The nest in question was about two inches high, composed of a very close satin-like texture. There were two parallel chambers placed perpendicularly, in which posi-

tion also the inhabitant reposed there during the day, going, as we presume, only abroad to prey during the night. But the most remarkable circumstance was, that the openings (two above and two below) were so elastic, that they shut almost as closely as the boat cocoon of the *Tortrix Chlorana* (see page 71). We observed this spider for several months, but at last it disappeared, and we took the nest out, under the notion that it might contain eggs; but we found none, and therefore conclude that it was only used as a day retreat. (J. R.) The account which Evelyn has given of these hunting-spiders is so interesting, that we must transcribe it.

"Of all sorts of insects," says he, "there is none has afforded me more divertisement than the *venatores* (hunters), which are a sort of *lupi* (wolves) that have their dens in rugged walls and crevices of our houses; a small brown and delicately-spotted kind of spiders, whose hinder legs are longer than the rest. Such I did frequently observe at Rome, which, espying a fly at three or four yards distance, upon the balcony where I stood, would not make directly to her, but crawl under the rail, till being arrived to the antipodes, it would steal up, seldom missing its aim; but if it chanced to want anything of being perfectly opposite, would, at first peep, immediately slide down again,—till, taking better notice, it would come the next time exactly upon the fly's back: but if this happened not to be within a competent leap, then would this insect move so softly, as the very shadow of the gnomon seemed not to be more imperceptible, unless the fly moved; and then would the spider move also in the same proportion, keeping that just time with her motion, as if the same soul had animated both these little bodies; and whether it were forwards, backwards, or to either side, without at all turning her body, like a well-managed horse: but if the capricious fly took wing and pitched upon another place behind our huntress, then would the spider whirl its body so nimbly about, as nothing could be imagined more swift: by which means she always kept the head towards her prey, though, to appearance, as immoveable as if it had been

a nail driven into the wood, till by that indiscernible progress (being arrived within the sphere of her reach) she made a fatal leap, swift as lightning, upon the fly, catching him in the pole, where she never quitted hold till her belly was full, and then carried the remainder home."

One feels a little sceptical, however, when he adds, "I have beheld them instructing their young ones how to hunt, which they would sometimes discipline for not well observing; but when any of the old ones did (as sometimes) miss a leap, they would run out of the field and hide themselves in their crannies, as ashamed, and haply not to be seen abroad for four or five hours after; for so long have I watched the nature of this strange insect, the contemplation of whose so wonderful sagacity and address has amazed me; nor do I find in any chase whatsoever more cunning and stratagem observed. I have found some of these spiders in my garden, when the weather, towards spring, is very hot, but they are nothing so eager in hunting as in Italy." *

We have only to add to this lively narrative, that the hunting-spider, when he leaps, takes good care to provide against accidental falls by always swinging himself from a good strong cable of silk, as Swammerdam correctly states,† and which anybody may verify, as one of the small hunters (*Salticus scenicus*), known by having its back striped with black and white like a zebra, is very common in Britain.

Mr. Weston, the editor of 'Bloomfield's Remains,' falls into a very singular mistake about hunting-spiders, imagining them to be web-weaving ones which have exhausted their materials, and which are therefore compelled to hunt. In proof of this he gives an instance which fell under his own observation![‡]

As a contrast to the little elastic satin nest of the hunter, we may mention the largest with which we are

* Evelyn's Travels in Italy.
† Book of Nature, part i. p. 24.
‡ Bloomfield's Remains, vol. ii. p. 61, *note*.

acquainted,—that of the labyrinthic spider (*Agelena labyrinthica*, WALCKENAER). Our readers must often have seen this nest spread out like a broad sheet in hedges, furze, and other low bushes, and sometimes on the ground. The middle of this sheet, which is of a close texture, is swung like a sailor's hammock, by silken ropes extended all around to the higher branches; but the whole curves upwards and backwards, sloping down to a long funnel-shaped gallery which is nearly horizontal at the entrance, but soon winds obliquely till it becomes quite perpendicular. This curved gallery is about a quarter of an inch in diameter, is much more closely woven than the sheet part of the web, and sometimes descends into a hole in the ground, though oftener into a group of crowded twigs, or a tuft of grass. Here the spider dwells secure, frequently resting with her legs extended from the entrance of the gallery, ready to spring out upon whatever insect may fall into her sheet net. She herself can only be caught by getting behind her and forcing her out into the web; but though we have often endeavoured to make her construct a nest under our eye, we have been as unsuccessful as in similar experiments with the common house spider (*Aranea domestica*). (J. R.)

The house spider's proceedings were long ago described by Homberg, and the account has been copied, as usual, by almost every subsequent writer. Goldsmith has, indeed, given some strange mis-statements from his own observations, and Bingley has added the original remark, that, after fixing its first thread, creeping along the wall, and joining it as it proceeds, it "*darts itself to the opposite side*, where the other end is to be fastened!"* Homberg's spider took the more circuitous route of travelling to the opposite wall, carrying in one of the claws the end of the thread previously fixed, lest it should stick in the wrong place. This we believe to be the correct statement, for as the web is always horizontal, it would seldom answer to commit a floating

* Animal Biography, iii. 470-1.

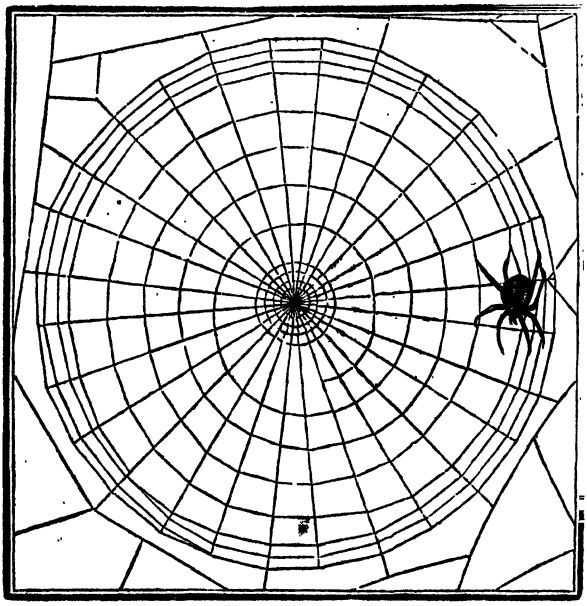
thread to the wind, as is done by other species. Homberg's spider, after stretching as many lines by way of *warp* as it deemed sufficient between the two walls of the corner which it had chosen, proceeded to cross this in the way our weavers do in adding the *woof*, with this difference, that the spider's threads were only laid on, and not interlaced.* The domestic spiders, however, in these modern days, must have forgot this mode of weaving, for none of their webs will be found to be thus regularly constructed!

The geometric, or net-working spiders (*Tendeuses*, Latr.), are as well known in most districts as any of the preceding; almost every bush and tree in the gardens and hedge-rows having one or more of their nets stretched out in a vertical position between adjacent branches. The common garden spider (*Epeira diadema*), and the long-bodied spider (*Tetragnatha extensa*), are the best known of this order.

The chief care of a spider of this sort is, to form a cable of sufficient strength to bear the net she means to hang upon it; and, after throwing out a floating line as above described, when it catches properly she doubles and redoubles it with additional threads. On trying its strength she is not contented with the test of pulling it with her legs, but drops herself down several feet from various points of it, as we have often seen, swinging and bobbing with the whole weight of her body. She proceeds in a similar manner with the rest of the framework of her wheel-shaped net; and it may be remarked that some of the ends of these lines are not simple, but in form of a Y, giving her the additional security of two attachments instead of one.

In constructing the body of the net, the most remarkable circumstance is her using her limbs as a measure, to regulate the distances of her *radii* or wheel-spokes, and the circular meshes interweaved into them. These are consequently always proportional to the size of the spider. She often takes up her station in the centre,

* Mém. de l'Acad. des Sciences pour 1707, p. 339.



Geometric Net of *Epeira diadema*.

but not always, though it is so said by inaccurate writers; for she as frequently lurks in a little chamber constructed under a leaf or other shelter at the corner of her web, ready to dart down upon whatever prey may be entangled in her net. The centre of the net is said also to be composed of more viscid materials than its suspensory lines,—a circumstance alleged to be proved by the former appearing under the microscope studded with globules of gum.* We have not been able to verify this distinction, having seen the suspensory lines as often studded in this manner as those in the centre. (J. R.)

* Kirby and Spence, Intr. i. 419.

Mason-Spiders.

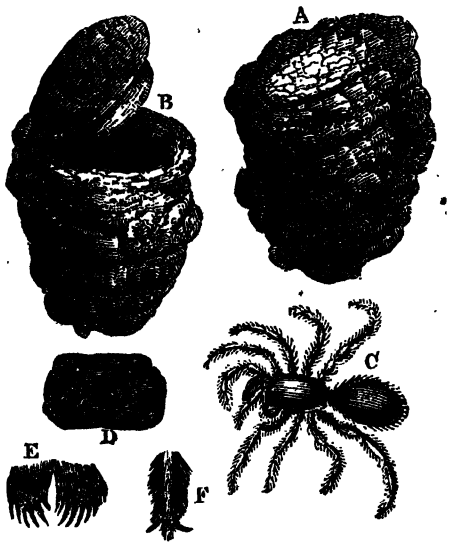
A no less wonderful structure is composed by a sort of spiders, natives of the tropics and the south of Europe, which have been justly called mason-spiders by M. Latreille. One of these (*Mygale nidulans*, Walckn.), found in the West Indies, "digs a hole in the earth obliquely downwards, about three inches in length, and one in diameter. This cavity she lines with a tough thick web, which, when taken out, resembles a leathern purse; but what is most curious, this house has a door with hinges, like the operculum of some sea-shells, and herself and family, who tenant this nest, open and shut the door whenever they pass and repass. This history was told me," says Darwin, "and the nest, with its door, shown me by the late Dr. Butt, of Bath, who was some years physician in Jamaica."*

The nest of a mason-spider, similar to this, has been obligingly put into our hands by Mr. Riddle, of Blackheath. It came from the West Indies, and is probably that of Latreille's clay-kneader (*Mygale cratiens*), and one of the smallest of the genus. We have since seen a pair of these spiders in possession of Mr. William Mello, of Blackheath. The nest is composed of very hard argillaceous clay, deeply tinged with brown oxide of iron. It is in form of a tube, about one inch in diameter, between six and seven inches long, and slightly bent towards the lower extremity—appearing to have been mined into the clay rather than built. The interior of the tube is lined with a uniform tapestry of silken web, of an orange-white colour, with a texture intermediate between India paper and very fine glove leather. But the most wonderful part of this nest is its entrance, which we look upon as the perfection of insect architecture. A circular door, about the size of a crown piece, slightly concave on the outside and convex within, is formed of more than a dozen layers of the same web which lines the interior, closely laid upon one another, and

* Darwin's Zoonomia, i. 253, 8vo. ed.

shaped so that the inner layers are the broadest, the outer being gradually less in diameter, except towards the hinge, which is about an inch long; and in consequence of all the layers being united there, and prolonged into the tube, it becomes the thickest and strongest part of the structure. The elasticity of the materials, also, gives to this hinge the remarkable peculiarity of acting like a spring, and shutting the door of the nest spontaneously. It is, besides, made to fit so accurately to the aperture, which is composed of similar concentric layers of web, that it is almost impossible to distinguish the joining by the most careful inspection. To gratify curiosity, the door has been opened and shut hundreds of times, without in the least destroying the power of the spring. When the door is shut, it resembles some of the lichens (*Lecidea*), or the leathery fungi, such as *Polyporus versicolor* (MICHELI), or, nearer still, the upper valve of a young oyster shell. The door of the nest, the only part seen above ground, being of a blackish-brown colour, it must be very difficult to discover. (J. R.)

Another mason-spider (*Mygale cæmentaria*, LATR.), found in the south of France, usually selects for her nest a place bare of grass, sloping in such a manner as to carry off the water, and of a firm soil, without rocks or small stones. She digs a gallery a foot or two in depth, and of a diameter (equal throughout) sufficient to admit of her easily passing. She lines this with a tapestry of silk glued to the walls. The door, which is circular, is constructed of many layers of earth kneaded, and bound together with silk. Externally, it is flat and rough, corresponding to the earth around the entrance, for the purpose, no doubt, of concealment: on the inside it is convex, and tapestried thickly with a web of fine silk. The threads of this door-tapestry are prolonged, and strongly attached to the upper side of the entrance, forming an excellent hinge, which, when pushed open by the spider, shuts again by its own weight, without the aid of spring hinges. When the spider is at home, and her door forcibly opened by an intruder, she pulls it strongly in-



Nest of the Mason-Spider.

A. The nest shut. B. The nest open. C. The spider, *Mygale cæmentaria*. D. The eyes magnified. E, F. Parts of the foot and claw magnified.

wards, and even when half-opened often snatches it out of the hand; but when she is foiled in this, she retreats to the bottom of her den, as her last resource.*

Rossi ascertained that the female of an allied species (*Mygale sauvagesii*, LATR.), found in Corsica, lived in one of these nests, with a numerous posterity. He destroyed one of these doors to observe whether a new one would be made, which it was: but it was fixed immoveably, without a hinge; the spider, no doubt, for-

* Mém. Soc. d'Hist. Nat. de Paris, An. vii.

tifying herself in this manner till she thought she might re-open it without danger.*

"The Rev. Revett Shepherd has often noticed, in the fen ditches of Norfolk, a very large spider (the species not yet determined) which actually forms a *raft* for the purpose of obtaining its prey with more facility. Keeping its station upon a ball of weeds about three inches in diameter, probably held together by slight silken cords, it is wafted along the surface of the water upon this floating island, which it quits the moment it sees a drowning insect. The booty thus seized it devours at leisure upon its raft, under which it retires when alarmed by any danger."† In the spring of 1830, we found a spider on some reeds in the Croydon Canal, which agreed in appearance with Mr. Shepherd's.

Among our native spiders there are several besides this one, which, not contented with a web like the rest of their congeners, take advantage of other materials to construct cells where, "hushed in grim repose," they "expect their insect prey." The most simple of those spider-cells is constructed by a longish-bodied spider (*Aranea holosericea*, Linn.), which is a little larger than the common hunting spider. It rolls up a leaf of the lilac or poplar, precisely in the same manner as is done by the leaf-rolling caterpillars, upon whose cells it sometimes seizes to save itself trouble, having first expelled, or perhaps devoured, the rightful owner. The spider, however, is not satisfied with the tapestry of the caterpillar, but always weaves a fresh set of her own, much more close and substantial.

Another spider, common in woods and copses (*Epeira quadrata?*) weaves together a great number of leaves to form a dwelling for herself, and in front of it she spreads her toils for entrapping the unwary insects which stray thither. These, as soon as caught, are dragged into her

* Mém. Soc. d'Hist. Nat. de Paris, An. vii. p. 125, and Latreille, Hist. Nat. Génér. viii. p. 163.

† Kirby and Spence, Intr. i. 425.

den, and stored up for a time of scarcity. Here also her eggs are deposited and hatched in safety. When the cold weather approaches, and the leaves of her edifice wither, she abandons it for the more secure shelter of a hollow tree, where she soon dies; but the continuation of the species depends upon eggs, deposited in the nest before winter, and remaining to be hatched with the warmth of the ensuing summer.

The spider's den of united leaves, however, which has just been described, is not always useless when withered and deserted; for the dormouse usually selects it as a ready-made roof for its nest of dried grass. That those old spiders' dens are not accidentally chosen by the mouse, appears from the fact, that out of about a dozen mouse-nests of this sort found during winter in a copse between Lewisham and Bromley, Kent, every second or third one was furnished with such a roof. (J. R.)

Diving Water-Spider.

Though spiders require atmospheric air for respiration, yet one species well known to naturalists is aquatic in its habits, and lives not only upon the surface but below the surface of the water, contriving to carry down with it a sufficiency of air for the support of life during a considerable period of time. Its subaqueous nest is in fact a sort of diving-bell, and constitutes a secure and most ingenious habitation. This spider does not like stagnant water, but prefers slow running streams, canals, and ditches, where she may often be seen, in the vicinity of London and elsewhere, living in her diving-bell, which shines through the water like a little globe of silver: her singular economy was first, we believe, described by Clerck,* L. M. de Lignac,† and De Geer.

"The shining appearance," says Clerck, "proceeds either from an inflated globule surrounding the abdomen, or from the space between the body and the water. The

* Aranei Suecici, Stockholm, 1757.

† Mém. des Araign. Aquat., 12mo. Paris, 1799.

spider, when wishing to inhale the air, rises to the surface, with its body still submersed, and only the part containing the spinneret rising just to the surface, when it briskly opens and moves its four teats. A thick coat of hair keeps the water from approaching or wetting the abdomen. It comes up for air about four times an hour or oftener, though I have good reason to suppose it can continue without it for several days together.

"I found in the middle of May one male and ten females, which I put into a glass filled with water, where they lived together very quietly for eight days. I put some duck-weed (*Lemna*) into the glass to afford them shelter, and the females began to stretch diagonal threads in a confused manner from it to the sides of the glass about half way down. Each of the females afterwards fixed a close bag to the edge of the glass, from which the water was expelled by the air from the spinneret, and thus a cell was formed capable of containing the whole animal. Here they remained quietly, with their abdomens in their cells, and their bodies still plunged in the water; and in a short time brimston-coloured bags of eggs appeared in each cell, filling it about a fourth part. On the 7th of July several young ones swam out from one of the bags. All this time the old ones had nothing to eat, and yet they never attacked one another as other spiders would have been apt to do."*

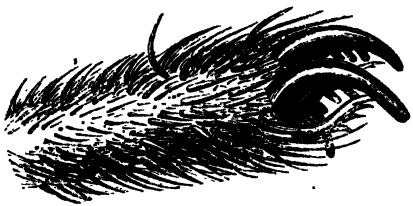
"These spiders," says De Geer, "spin in the water a cell of strong, closely woven, white silk in the form of half the shell of a pigeon's egg, or like a diving-bell. This is sometimes left partly above water, but at others is entirely submersed, and is always attached to the objects near it by a great number of irregular threads. It is closed all round, but has a large opening below, which, however, I found closed on the 15th of December, and the spider living quietly within, with her head downwards. I made a rent in this cell, and expelled the air, upon which the spider came out; yet though she appeared to have been laid up for three months in her

* Clerck, Aranei Suecici, cap. viii.

winter quarters, she greedily seized upon an insect and sucked it. I also found that the male as well as the female constructs a similar subaqueous cell, and during summer no less than in winter."* We have recently kept one of these spiders for several months in a glass of water, where it built a cell half under water, in which it laid its eggs.

Cleanliness of Spiders.

When we look at the viscid material with which spiders construct their lines and webs, and at the rough, hairy covering (with a few exceptions) of their bodies, we might conclude, that they would be always stuck over with fragments of the minute fibres which they produce. This, indeed, must often happen, did they not take careful precautions to avoid it; for we have observed that they seldom, if ever, leave a thread to float at random, except when they wish to form a bridge. When a spider drops along a line, for instance, in order to ascertain the strength of her web, or the nature of the place below her, she invariably, when she re-ascends, coils it up into a little ball, and throws it away. Her



Triple-clawed foot of a Spider, magnified.

claws are admirably adapted for this purpose, as well as for walking along the lines, as may be readily seen by a magnifying glass.

There are three claws, one of which acts as a thumb,

* De Geer, Mém. des Insectes, vii. 312.

the others being toothed like a comb, for gliding along the lines. This structure, however, unfits it to walk, as flies can do, upon any upright polished surface like glass; although the contrary* is erroneously asserted by the Abbé de la Pluche. Before she can do so, she is obliged to construct a ladder of ropes, as Mr. Blackwall remarks,† by elevating her spinneret as high as she can, and laying down a step upon which she stands to form a second; and so on, as any one may try by placing a spider at the bottom of a very clean wine glass.

The hairs of the legs, however, are always catching bits of web and particles of dust; but these are not suffered to remain long. Most people may have remarked that the house-fly is ever and anon brushing its feet upon one another to rub off the dust, though we have not seen it remarked in authors that spiders are equally assiduous in keeping themselves clean. They have, besides, a very efficient instrument in their mandibles or jaws, which, like their claws, are furnished with teeth; and a spider which appears to a careless observer as resting idly, in nine cases out of ten will be found slowly combing her legs with her mandibles, beginning as high as possible on the thigh, and passing down to the claws. The flue which she thus combs off is regularly tossed away.

With respect to the house-spider (*A. domestica*), we are told in books, that "she from time to time clears away the dust from her web, and sweeps the whole by giving it a shake with her paw, so nicely proportioning the force of her blow, that she never breaks any thing."‡ That spiders may be seen shaking their webs in this manner, we readily admit; though it is not, we imagine, to clear them of dust, but to ascertain whether they are sufficiently sound and strong.

We recently witnessed a more laborious process of cleaning a web than merely shaking it. On coming down the Maine by the steam-boat from Frankfort, in

* Spectacle de la Nature, i. 58. † Linn. Trans. vol. xv.
‡ Spectacle de la Nature, i. p. 61.

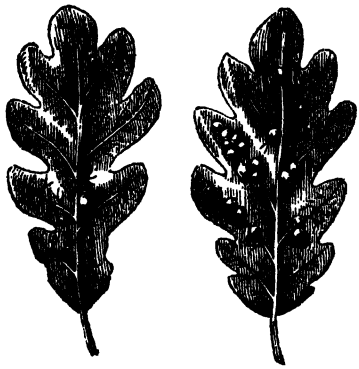
August 1829, we observed the geometric-net of a conic-spider (*Epeira conica*, WALCK.) on the framework of the deck, and as it was covered with flakes of soot from the smoke of the engine, we were surprised to see a spider at work on it; for, in order to be useful, this sort of net must be clean. Upon observing it a little closely, however, we perceived that she was not constructing a net, but dressing up an old one; though not, we must think, to save trouble, so much as an expenditure of material. Some of the lines she dexterously stripped of the flakes of soot adhering to them; but in the greater number, finding that she could not get them sufficiently clean, she broke them quite off, bundled them up, and tossed them over. We counted five of these packets of rubbish which she thus threw away, though there must have been many more, as it was some time before we discovered the manœuvre, the packets being so small as not to be readily perceived, except when placed between the eye and the light. When she had cleared off all the sooted lines, she began to replace them in the usual way; but the arrival of the boat at Mentz put an end to our observations. (J. R.) Bloomfield, the poet, having observed the disappearance of these bits of ravelled web, imagined that the spider swallowed them; and even says that he observed a garden spider moisten the pellets before swallowing them!* Dr. Lister, as we have already seen, thought the spider retracted the threads within the abdomen.

* Remains, ii. 62-5. It is a remarkable fact, as recorded from personal observation by Mr. Bell (British Reptiles), that the toad swallows the cuticle detached from its body during the moult which it undergoes.

CHAPTER XIX.

Structures of Gall-Flies and Aphides.

MANY of the processes which we have detailed bear some resemblance to our own operations of building with materials cemented together; but we shall now turn our attention to a class of insect-architects, who cannot, so far as we know, be matched in prospective skill by any of the higher orders of animals. We refer to the numerous family which have received the name of gall-flies,—a family which, as yet, is very imperfectly understood, their economy being no less difficult to trace, than their species is to arrange in the established systems of classification; though the latter has been recently much improved by Mr. Westwood.



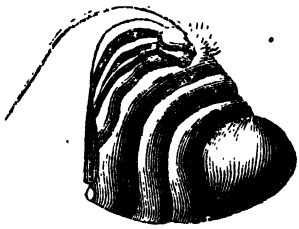
Small berry-shaped galls of the oak leaf, produced by *Cynips quercus folii?*

One of the most simple and very common instances of the nests constructed by gall-insects, may be found in abundance during the summer, on the leaves of the rose-tree, the oak, the poplar, the willow (*Salix viminalis*), and many other trees, in the globular form of a berry, about the size of a currant, and usually of a green colour, tinged with red, like a ripe Alban or Baltimore apple.

When this pseudo-apple in miniature is cut into, it is found to be fresh, firm, juicy, and hollow in the centre, where there is either an egg or a grub safely lodged, and protected from all ordinary accidents. Within this hollow ball the egg is hatched, and the grub feeds securely on its substance, till it prepares for its winter sleep, before changing into a gall-fly (*Cynips*) in the ensuing summer. There is a mystery as to the manner in which this gall-fly contrives to produce the hollow miniature-apples, each enclosing one of her eggs; and the doubts attendant upon the subject cannot, so far as our present knowledge extends, be solved, except by plausible conjecture. Our earlier naturalists were of opinion that it was the grub which produced the galls, by eating, when newly hatched, through the cuticle of the leaf, and remaining till the juices flowing from the wound enveloped it, and acquired consistence by exposure to the air. This opinion, however, plausible as it appeared to be, was at once disproved by finding unhatched eggs on opening the galls.

There can be no doubt, indeed, that the mother gall-fly makes a hole in the plant for the purpose of depositing her eggs. She is furnished with an admirable ovipositor for that express purpose, and Swammerdam actually saw a gall-fly thus depositing her eggs, and we have recently witnessed the same in several instances. In some of these insects the ovipositor is conspicuously long, even when the insect is at rest; but in others, not above a line or two of it is visible, till the belly of the insect be gently pressed. When this is done to the fly that produces the currant-gall of the oak, the ovipositor may be seen issuing from a sheath in form of a small

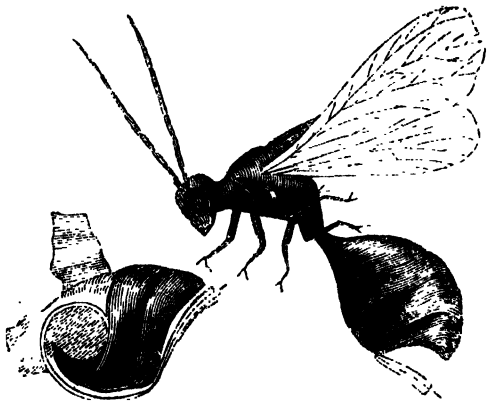
curved needle, of a chesnut-brown colour, and of a horny substance, and three times as long as it at first appeared.



Ovipositor of gall-fly, greatly magnified.

What is most remarkable in this ovipositor is, that it is much longer than the whole body of the insect, in whose belly it is lodged in a sheath, and, from its horny nature, it cannot be either shortened or lengthened. It is on this account that it is bent into the same curve as the body of the insect. The mechanism by which this is effected is similar to that of the tongue of the woodpeckers (*Picidæ*), which, though rather short, can be darted out far beyond the beak, by means of a forked bone at the root of the tongue, which is thin and rolled up like the spring of a watch. The base of the ovipositor of the gall-fly is, in a similar way, placed near the anus, runs along the curvature of the back, makes a turn at the breast, and then, following the curve of the belly, appears again near where it originates. We copy from Réaumur his accurate sketch of this remarkable structure.

With this instrument the mother gall-fly pierces the part of a plant which she selects, and, according to our older naturalists, "ejects into the cavity a drop of her corroding liquor, and immediately lays an egg or more there; the circulation of the sap being thus interrupted, and thrown, by the poison, into a fermentation that burns the contiguous parts and changes the natural



Gall-fly, and mechanism of ovipositor, greatly magnified.

colour. The sap, turned from its proper channel, extravasates and flows round the eggs, while its surface is dried by the external air, and hardens into a vaulted form."* Kirby and Spence tell us, that the parent fly introduces her egg "into a puncture made by her curious spiral sting, and in a few hours it becomes surrounded with a fleshy chamber."† M. Virey says, the gall tubercle is produced by irritation, in the same way as an inflamed tumor in an animal body, by the swelling of the cellular tissue and the flow of liquid matter, which changes the organization, and alters the natural external form.‡ This seems to be the received doctrine at present in France.§

Sprengel, speaking of the rose-willow, says, the insect in spring deposits its eggs in the leaf buds. "The new stimulus attracts the sap,—the type of the part becomes

* Spectacle de la Nature, i. 119.
† Introd. ii. 449.
‡ Hist. des Mœurs et de l'Instinct, vol. ii.
§ Entomologie par R. A. E. page 242. Paris, 1826.

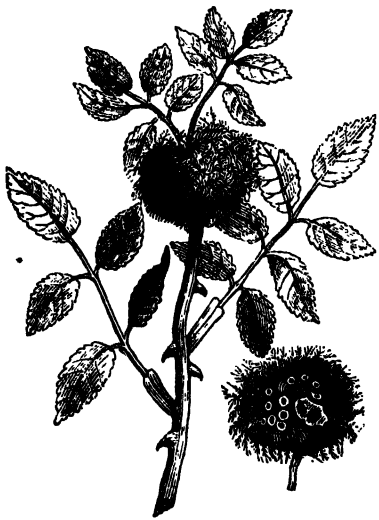
changed, and from the prevailing acidity of the anima juice, it happens, that in the rose and stock-shaped leave which are pushed out, a red instead of a green colour i evolved." *

Without pretending positively to state facts which are perhaps, beyond human penetration, we may view the process in a rather different light. (J. R.) Following the analogy of what is *known* to occur in the case of the saw-flies (see page 150), after the gall-fly has made a puncture and pushed her egg into the hole, we may suppose that she covers it over with some adhesive gluten or gum, or the egg itself, as is usual among moths, &c., may be coated over with such a gluten. In either of these two cases, the gluten will prevent the sap that flows through the puncture from being scattered over the leaf and wasted; and the sap, being thus confined to the space occupied by the eggs, will expand and force outwards the pellicle of gluten that confines it, till becoming thickened by evaporation and exposure to the air, it at length shuts up the puncture, stops the further escape of the sap, and the process is completed. This explanation will completely account for the globular form of the galls alluded to; that is, supposing the egg of the gall-fly to be globular, and covered or coated with a pellicle of gluten of uniform thickness, and consequently opposing uniform resistance, or rather uniform expansibility, to the sap pressing from within. It will also account for the remarkable uniformity in the size of the gall apples; for the punctures and the eggs being uniform in size, and the gluten, by supposition, uniform in quantity, no more than the same quantity of sap can escape in such circumstances.

But though this explanation appears to be plausible, it is confessedly conjectural; for though Swammerdam detected a gall-fly in the act of depositing her eggs, he did not attend to this circumstance; and in the instances which we have observed, some unlucky accident always prevented us from following up our observations. The

* Elements of the Philosophy of Plants, Eng. Trans., p. 285.

indefatigable Réaumur, on one occasion, thought he would make sure of tracing the steps of the process in the case of the gall-fly which produces the substance called *bedeguar* on the wild rose-tree, and to which we shall presently advert. His plan was to enclose in a box, in which a brood of flies had just been produced from a bedeguar, a living branch from a wild rose-tree; but, to his great disappointment, no eggs were laid, and no bedeguar formed. Upon further investigation, he discovered that the brood of flies produced from the bedeguar were not the genuine bedeguar insects at all, but one of the parasite ichneumons (*Callimone Bedeguaris*, STEPHENS), which had surreptitiously deposited their eggs there, in order to supply their young with the bedeguar grubs, all of which they appeared to have



Bedeguar Gall of the Rose, produced by *Cynips Rosæ*.

devoured. It may prove interesting to look into the remarkable structure of the bedeguar itself, which is very different from the globular galls above described.

One of the bristles of the Bedeguar of the rose magnified.

The gall-fly of the willow (*Cynips viminalis*) deposits, as we have just seen, only a single egg on one spot; but the bedeguar insect lays a large cluster of eggs on the extremity of a growing branch of the wild rose-tree, making, probably, a proportionate number of punctures to procure materials for the future habitation of her young progeny. As in the former case, also, each of these eggs becomes (as we may suppose) surrounded with the sap of the rose, enclosed in a pellicle of gluten. The gluten, however, of the bedeguar insect is not, it would appear, sufficiently tenacious to confine the flowing sap within the dimensions of any of the little clustered globes containing the eggs, for it oozes out from numerous cracks or pores in the pellicle; which cracks or pores, however, are not large enough to admit a human hair. But this, so far from being a defect in the glutinous pellicle of the bedeguar fly, is, as we shall presently see, of great utility. The sap which issues from each of these pores, instead of being evaporated and lost, shoots out into a reddish-coloured, fibrous bristle.

It is about half an inch long, and, from the natural tendency of the sap of the rose-tree to form prickles, these are all over studded with weak pricklets. The bedeguar, accordingly, when fully formed, has some resemblance, at a little distance, to a tuft of reddish-brown hair or moss stuck upon the branch. Sometimes this tuft is as large as a small apple, and of a rounded but irregular shape; at other times it is smaller, and in one

instance mentioned by Réaumur, only a single egg had been laid on a rose leaf, and, consequently, only one tuft was produced. Each member of the congeries is furnished with its own tuft of bristles, arising from the little hollow globe in which the egg or the grub is lodged.

The prospective wisdom of this curious structure is admirable. The bedeguar grubs live in their cells through the winter, and as their domicile is usually on one of the highest branches, it must be exposed to every severity of the weather. But the close, non-conducting, warm, mossy collection of bristles, with which it is surrounded, forms for the soft, tender grubs a snug protection against the winter's cold, till, through the influence of the warmth of the succeeding summer, they undergo their final change into the winged state; preparatory to

Artichoke Gall of the Oak-bud, with Gall-fly (*Cynips quercus gemmæ*), natural size, and its ovipositor (*a*) magnified.

which they eat their way with their sharp mandible through the walls of their little cells, which are now s hard as to be cut with difficulty by a knife. (J. R.)

Another structure, similar in principle, though differen in appearance, is very common upon oak-trees, the ter mination of a branch being selected as best suited for the purpose. This structure is rather larger than a filbert and is composed of concentric leaves diverging from the base, and expanding upwards, somewhat like an artichoke. Whether this leafy structure is caused by a superinduced disease, as the French think, or by the form of the pores in the pellicle of gluten surrounding the eggs, or rather by the tendency of the exuding sap of the oak to form leaves, has not been ascertained; but that it is intended, as in the case of the bedeguar, to afford an efficient protection against the weather to the included eggs or grubs, there can be no doubt.

From the very nature of the process of forming willow-galls, bedeguar, and the artichoke of the oak, whatever theory be adopted, it will be obvious that their growth must be rapid; for the thickening of the exuded sap, which is quickly effected by evaporation, will soon obstruct and finally close the orifice of the puncture made by the parent insect. It is accordingly asserted by Réaumur and other observers, that all the species of galls soon reach their full growth.

A very minute reddish-coloured grub feeds upon dyer's broom (*Genista*), producing a sort of gall, frequently globular, but always studded with bristles, arising from the amorphous leaves. The stem of the shrub passes through this ball, which is composed of a great number of leaves, shorter and broader than natural, and each rolled into the form of a horn, the point of which ends in a bristle. In the interior we find a thick fleshy substance, serving to sustain the leaves, and also for the nourishment of the grubs, some of which are within and some between the leaves. They are in prodigious numbers,—hundreds being assembled in the same gall, and so minute as scarcely to be perceived without the aid of a magnifying glass. The bud of the plant attacked

by those grubs, instead of forming a shoot, pushes out nothing but leaves, and these are all rolled and turned round the stem. Some shrubs have several of these galls, which are of various sizes, from that of a filbert to that of a walnut.

Leafy Gall of Dyer's Broom, produced by *Cynips genistæ?*
A. gall, natural size; B. a leafet magnified.

A similar but still more beautiful production is found upon one of the commonest of our indigenous willows (*Salix purpurea*), which takes the name of *rose-willow*, more probable from this circumstance than from the red colour of its twigs. The older botanists, not being aware of the cause of such excrescences, considered the plants so affected as distinct species; and old Gerard, accordingly, figures and describes the rose-willow as "not only making a gallant show, but also yielding a most cooling air in the heat of summer, being set up in houses for decking the same." The production in question, however, is nothing more than the effect produced by a species of gall-fly (*Cynips salicis*) depositing

its eggs in the terminal shoot of a twig, and, like the bedeguar and the oak artichoke, causing leaves to spring out, of a shape totally different from the other leaves of the tree, and arranged very much like the petals of a rose. Decandolle says it is found chiefly on the *Salix helix*, *S. alba*, and *S. riparia*.*

A production very like that of the rose-willow may be commonly met with on the young shoots of the hawthorn, the growth of the shoot affected being stopped, and a crowded bunch of leaves formed at the termination. These leaves, beside being smaller than natural, are studded with short bristly prickles, from the sap (we may suppose) of the hawthorn being prevented from rising into a fresh shoot, and thrown out of its usual course in the formation of the arms. These bristles appear indiscriminately on both sides of the leaves, some of which are bent inwards, while others diverge in their natural manner.

This is not caused by the egg or grub of a true gall-fly, but by the small white tapering grub of some dipterous insect, of which we have not ascertained the species, but which is, probably, a *cecidomyia*. Each terminal shoot is inhabited by a number of these—not lodged in cells, however, but burrowing indiscriminately among the half-withered brown leaves which occupy the centre of the production. (J. R.)

A more remarkable species of gall than any of the above we discovered in June, 1829, on the twig of an oak in the grounds of Mr. Perkins, at Lee, in Kent. When we first saw it, we imagined that the twig was beset with some species of the lanigerous aphides, similar to what is vulgarly called the American or white blight (*aphis lanata*); but on closer examination we discarded this notion. The twig was indeed thickly beset with a white downy, or rather woolly, substance around the stem at the origin of the leaves, which did not appear to be affected in their growth, being well formed, healthy, and luxuriant. We could not doubt that the woolly

* Flore Franç. Disc. Préliminaire.

substance was caused by some insect; but though we cut out a portion of it, we could not detect any egg or grub, and we therefore threw the branch into a drawer, intending to keep it as a specimen, whose history we might complete at some subsequent period.

A few weeks afterwards, on opening this drawer, we were surprised to see a brood of several dozens of a species of gall-fly (*Cynips*), similar in form and size to that whose eggs cause the bedeguar of the rose, and differing only in being of a lighter colour, tending to a yellowish brown. We have since met with a figure and description of this gall in Swammerdam. We may remark that the above is not the first instance which has occurred in our researches, of gall insects outliving the withering of the branch or leaf from which they obtain their nourishment.

The woolly substance on the branch of the oak which we have described was similarly constituted with the bedeguar of the rose, with this difference, that instead of the individual cells being diffused irregularly through the mass, they were all arranged at the off-goings of the

Semi Gall of the Hawthorn, produced by *Cecidomyia?* drawn from a specimen.

Woolly Gall of the Oak, less than the natural size, caused by a *Cynips*, and drawn from a specimen.

leaf-stalks, each cell being surrounded with a covering of the vegetable wool, [illegible] stimulus of the parent egg, or its [illegible], had caused to grow, and from each cell a [illegible]ect fly had issued. We also remarked that there were several small groups of individual cells, each of which groups was contained in a species of calyx or cup of leaf-scales, as occurs also in the well-known gall called the oak-apple.

We were anxious to watch the proceedings of these flies in the deposition of their eggs, and the subsequent developments of the gall-growths; and endeavoured for that purpose to procure a small oak plant in a garden-pot; but we did not succeed in this; and though they alighted on rose and sweet-briar trees, which we placed in their way, we never observed that they deposited any eggs upon them. In a week or two the whole brood died, or disappeared. (J. R.)

There are some galls, formed on low-growing plants, which are covered with down, hair, or wool, though by no means so copiously as the one which we have just described. Among the plants so affected are the germander speedwell, wild thyme, ground-ivy, and others to which we shall afterwards advert.

Oak-apple Galls, one being cut open to show the vessels running to granules.

The well-known oak-apple is a very pretty example of the galls formed by insects; and this, when compared with other galls which form on the oak, shows the remarkable difference produced on the same plant by the punctures of insects of different species. The oak-apple is commonly as large as a walnut or small apple, rounded, but not quite spherical, the surface being irregularly depressed in various places. The skin is smooth, and tinged with red and yellow, like a ripe apple; and at the base there is, in the earlier part of the summer, a calyx or cup of five or six small brown scaly leaves; but these fall off as the season advances. If an oak-apple be cut transversely, there is brought into view a number of oval granules, each containing a grub; and embedded in a fruit-looking fleshy substance, having fibres running through it. As these fibres, however, run in the direc-

tion of the stem, they are best exhibited by a vertical section of the gall; and this also shows the remarkable peculiarity of each fibre terminating in one of the granules, like a foot-stalk, or rather like a vessel for carrying nourishment. Réaumur, indeed, is of opinion that these fibres are the diverted nervures of the leaves, which would have sprung from the bud in which the gall-fly had inserted her eggs, and actually do carry sap-vessels throughout the substance of the gall.

Réaumur says the perfect insects (*Cynips quercus*) issued from his galls in June and the beginning of July, and were of a reddish-amber colour. We have procured insects, agreeing with Réaumur's description, from galls formed on the bark or wood of the oak, at the line of junction between the root and the stem. These galls are precisely similar in structure to the oak-apple, and are probably formed at a season when the fly perceives, instinctively, that the buds of the young branches are unfit for the purpose of nidification.

Root Galls of the Oak, produced by *Cynips quercus inferus?* drawn from a specimen.

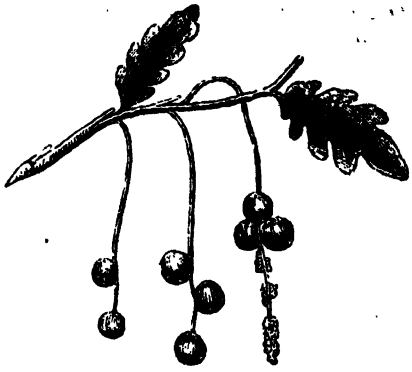
There is another oak-gall, differing little in size and appearance from the oak-apple, but which is very different in structure, as, instead of giving protection and nourishment to a number of grubs, it is only inhabited by one. This sort of gall, besides, is hard and woody on the outside, resembling a little wooden ball of a yellowish colour, but internally of a soft, spongy texture. The latter substance, however, incloses a small hard gall, which is the immediate residence of the included insect. Galls of this description are often found in clusters of from two to seven, near the extremity of a

branch, not incorporated, however, but distinctly separate.

We have obtained a fly very similar to this from a very common gall, which is formed on the branches of the willow. Like the one-celled galls just described, this is of a hard, ligneous structure, and forms an irregular protuberance, sometimes at the extremity, and sometimes on the body, of a branch. But instead of one, this has a considerable number of cells, irregularly distributed through its substance. The structure is somewhat spongy, but fibrous; and externally the bark is smoother than that of the branch upon which it grows. (J. R.)

Woody Gall on a Willow branch, drawn from a specimen.

The currant-galls (as the French call them) of the oak are exactly similar, when formed on the leaves, to those which we have first described as produced on the leaves of the willow and other trees. But the name of currant-gall seems still more appropriate to an excrescence which grows on the catkins of the oak, giving them very much the appearance of a straggling bunch of currants or bird-cherries. The galls resemble currants which have fallen from the tree before being ripe. These galls do not seem to differ from those formed on the leaves of the



Currant Gall of the catkins of the Oak, produced by *Cynips quercus pedunculi?*

oak; and are probably the production of the same insect, which selects the catkin in preference, by the same instinct that the oak-apple gall-fly, as we have seen, sometimes deposits its eggs in the bark of the oak near the root.

The gall of the oak, which forms an important dye-stuff, and is used in making writing-ink, is also produced by a *Cynips*, and has been described in the 'Library of Entertaining Knowledge' (Vegetable Substances, p. 16). The employment of the *Cynips psenes* for ripening figs is described in the same volume, p. 244.

Gall of a Hawthorn Weevil.

In May, 1829, we found on a hawthorn at Lee, in Kent, the leaves at the extremity of a branch neatly folded up in a bundle, but not quite so closely as is usual in the case of leaf-rolling caterpillars. On opening them, there was no caterpillar to be seen, the centre being occupied with a roundish, brown-coloured, woody substance, similar to some excrescences made by gall-

insects (*Cynips*). Had we been aware of its real nature, we should have put it immediately under a glass or in a box, till the contained insect had developed itself; but instead of this, we opened the ball, where we found a small yellowish grub coiled up, and feeding on the exuding juices of the tree. As we could not replace the grub in its cell, part of the walls of which we had unfortunately broken, we put it in a small pasteboard box with a fresh shoot of hawthorn, expecting that it might construct a fresh cell. This, however, it was probably incompetent to perform: it did not at least make the attempt, and neither did it seem to feed on the fresh branch, keeping in preference to the ruins of its former cell. To our great surprise, although it was thus exposed to the air, and deprived of a considerable portion of its nourishment, both from the part of the cell having been broken off, and from the juices of the branch having been dried up, the insect went through its regular

Ball of the Hawthorn Weevil, drawn from specimen.
a. Opened to show the grub.

changes, and appeared in the form of a small greyish-brown beetle of the weevil family. The most remarkable circumstance in the case in question, was the appa-

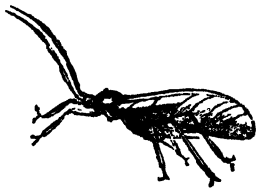
rent inability of the grub to construct a fresh cell after the first was injured,—proving, we think, beyond a doubt, that it is the puncture made by the parent insect when the egg is deposited that causes the exudation and subsequent concretion of the juices forming the gall. These galls were very abundant during the summer of 1830. (J. R.)

A few other instances of beetles producing galls are recorded by naturalists. Kirby and Spence have ascertained, for example, that the bumps formed on the roots of kedlock or charlock (*Sinapis arvensis*) are inhabited by the larvæ of a weevil (*Curculio contractus*, MARSHAM; and *Rhynchænus assimilis*, FABR.); and it may be reasonably supposed that either the same or similar insects cause the clubbing of the roots of cabbages, and the knob-like galls on turnips, called in some places the *anbury*. We have found them also infesting the roots of the holyhock (*Alcea rosea*). They are evidently beetles of an allied genus which form the woody galls sometimes met with on the leaves of the guelder-rose (*Viburnum*), the lime-tree (*Tilia europæa*), and the beech (*Fagus sylvatica*).

There are also some two-winged flies which produce woody galls on various plants, such as the thistle-fly (*Tephritis cardui*, LATR.). The grubs of this pretty fly produce on the leaf-stalks of thistles an oblong woody knob. On the common white briony (*Bryonia dioica*) of our hedges may be found a very pretty fly of this genus, of a yellowish brown colour, with pellucid wings, waved much like those of the thistle-fly with yellowish brown. This fly lays its eggs near a joint of the stem, and the grubs live upon its substance. The joint swells out into an oval form, furrowed in several places, and the fly is subsequently disclosed. In its perfect state, it feeds on the blossom of the briony. (J. R.) Flies of another minute family, the gall-gnats (*Cecidomyiæ*, LATR.), pass the first stage of their existence in the small globular cottony galls which abound on germander speedwell (*Veronica chamædrys*), wild thyme (*Thymus serpyllum*), and ground-ivy (*Glechoma hederacea*). The

latter is by no means uncommon, and may be readily recognised.

Certain species of plant-lice (*Aphides*), whose complete history would require a volume, produce excrescences upon plants which may with some propriety be termed galls, or semi-galls. Some of these are without any aperture, whilst others are in form of an inflated vesicle, with a narrow opening on the under side of a leaf, and expanding (for the most part irregularly) into a rounded knob on its upper surface. The mountain-ash (*Pyrus aucuparia*) has its leaves and young shoots frequently affected in this way, and sometimes exhibits galls larger than a walnut or even than a man's fist; at other times they do not grow larger than a filbert. Upon opening one of these, they are found to be filled with the *aphides sorbi*. If taken at an early stage of their growth, they are found open on the under side of the leaf, and inhabited only by a single female aphis, pregnant with a numerous family of young. In a short time, the aperture becomes closed, in consequence of the insect making repeated punctures round its edge, from which sap is exuded, and forms an additional portion of the walls of the cell.



A Plant-Louse (*Aphis*), magnified.

In this early stage of its growth, however, the gall does not, like the galls of the cynips, increase very much in dimensions. It is after the increase of the inhabitants by the young brood that it grows with considerable rapidity; for each additional insect, in order to

procure food, has to puncture the wall of the chamber and suck the juices, and from the punctures thus made the sap exudes, and enlarges the walls. As those galls are closed all round in the more advanced state, it does not appear how the insects can ever effect an exit from their imprisonment.

A much more common production, allied to the one just described, may be found on the poplar in June and July. Most of our readers may have observed, about Midsummer, a small snow-white tuft of downy-looking substance floating about on the wind, as if animated. Those tufts of snow-white down are never seen in numbers at the same time, but generally single, though some dozens of them may be observed in the course of one day. This singular object is a four-winged fly (*Eriosoma populi*, LEACH), whose body is thickly covered with long down—a covering which seems to impede its flight, and make it appear more like an inanimate substance floating about on the wind, than impelled by the volition of a living animal. This pretty fly feeds upon the fresh juices of the black poplar, preferring that of the leaves and leaf-stalks, which it punctures for this purpose with its beak. It fixes itself with this design to a suitable place upon the principal nervure of the leaf, or upon the leaf-stalk, and remains in the same spot till the sap, exuding through the punctures, and thickening by contact with the air, surrounds it with a thick fleshy wall of living vegetable substance, intermediate in texture between the wood and the leaf, being softer than the former and harder than the latter. In this snug little chamber, secure from the intrusion of lady-birds and the grubs of aphidivorous flies (*Syrphi*), she brings forth her numerous brood of young ones, who immediately assist in enlarging the extent of their dwelling, by puncturing the walls. In one respect, however, the galls thus formed differ from those of the mountain-ash just described,—those of the poplar having always an opening left into some part of the cell, and usually in that portion of it which is elongated into an obtuse beak. From this opening the young, when arrived at the winged state,

make their exit, to form new colonies; and, during their migrations, attract the attention of the most incurious by the singularity of their appearance. (J. R.)

Galls produced on the leaves and leaf-stalks of the Poplar by *Eriosoma populi*, with the various forms of the insects, winged, not winged, and covered with wool, both of the natural size and magnified.

On the black poplar there may be found, later in the season than the preceding, a gall of a very different form, though, like the other, it is for the most part on the leaf-stalk. The latter sort of galls are of a spiral form; and though they are closed, they open upon slight pressure, and appear to be formed of two laminæ, twisted so as to unite. It is at this opening that an aperture is formed spontaneously for the exit of the insects, when

arrived at a perfect state. In galls of this kind we find aphides, but of a different species from the lanigerous ones, which form the horn-shaped galls above described.

Leaf-Rolling Aphides.

It may not be improper to introduce here a brief sketch of some other effects, of a somewhat similar kind, produced on leaves by other species of the same family (*Aphidæ*). In all the instances of this kind which we have examined, the form which the leaf takes serves as a protection to the insects, both from the weather and from depredators. That there is design in it appears from the circumstance of the aphides crowding into the embowering vault which they have formed; and we are not quite certain whether they do not puncture certain parts of the leaf for the very purpose of making it arch over them; at least, in many cases, such as that of the hop-fly (*Aphis humuli*), though the insects are in countless numbers, no arching of the leaves follows. The rose-plant louse, again (*Aphis rosæ*), sometimes arches the leaves, but more frequently gets under the protecting folds of the half-expanded leaf-buds. (J. R.)

One of the most common instances of what we mean occurs on the leaves of the currant-bush, which may often be observed raised up into irregular bulgings, of a reddish-brown colour. On examining the under side of such a leaf, there will be seen a crowd of small insects, some with and some without wings, which are the *Aphides ribis* in their different stages, feeding securely and socially on the juices of the leaf.

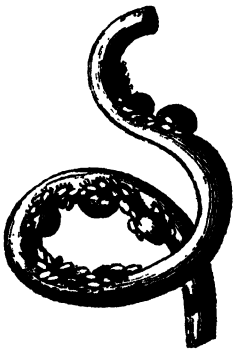
The most remarkable instance of this, however, which we have seen, occurs on the leaves of the elm, and is caused by the *Aphis ulmi*. The edge of an elm-leaf inhabited by those aphides is rolled up in an elegant convoluted form, very much like a spiral shell; and in the embowered chamber thus formed, the insects are secure from rain, wind, and, partially, from the depredations of carniverous insects. One of their greatest enemies, the lady-bird (*Coccinella*), seldom ventures, as we have re-

Leaf of the Currant-bush, bulged out by the *Aphis ribis*.

marked, into concealed corners, except in cold weather, and contrives to find food enough among the aphides which feed openly and unprotected, such as the zebra aphides of the alder (*Aphides sambuci*). The grubs, however, of the lady-bird, and also those of the aphidivorous flies (*Syrphi*), may be found prying into the most secret recesses of a leaf to prey upon the inhabitants, whose slow movements disqualify them from effecting an escape. (J. R.)

The effects of the puncture of aphides on growing plants is strikingly illustrated in the shoots of the lime-tree and several other plants, which become bent and contorted on the side attacked by the insects, in the same way that a shoot might warp by the loss of its juices on the side exposed to a brisk fire. The curvings thus effected become very advantageous to the insects, for the leaves sprouting from the twig, which naturally grow at a distance from each other, are brought close together in a bunch, forming a kind of nosegay, that

conceals all the contour of the sprig, as well as the insects which are embowered under it, protecting them against the rain and the sun, and, at the same time, hiding them from observation. It is only requisite, however, where they have formed bowers of this description, to raise the leaves, in order to see the little colony of the aphides,—or the remains of those habitations which they have abandoned. We have sometimes observed sprigs of the lime-tree, of a thumb's thickness, portions of which resembled spiral screws; but we could not certainly have assigned the true cause for this twisting, had we not been acquainted with the manner in which aphides contort the young shoots of this tree.* The shoots of the gooseberry and the willow are sometimes contorted in the same way, but not so strikingly as the shoots of the lime.

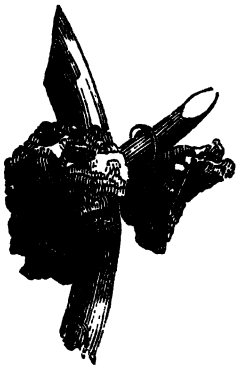


Shoot of the Lime-tree contorted by the punctures of the *Aphis Tiliæ*.

Pseudo-Galls.

It may not be out of place to mention here certain anomalous excrescences upon trees and other plants, which, though they much resemble galls, are not so distinctly traceable to the operations of any insect. In

* Réaumur, vol. iii.



Pseudo-Gall of the Bramble, drawn from a specimen.

our researches after galls, we have not unfrequently met with excrescences which so very much resemble them, that before dissection we should not hesitate to consider them as such, and predict that they formed the nidus of some species of insects. In more instances than one we have felt so strongly assured of this, that we have kept several specimens for some months, in nurse-boxes, expecting that in due time the perfect insects would be disclosed.

One of these pseudo-galls occurs on the common bramble (*Rubus fruticosus*), and bears some resemblance to the bedeguar of the rose when old and changed by weather. It clusters round the branches in the form of irregular granules, about the size of a pea, very much crowded, the whole excrescence being rather larger than a walnut. We expected to find this excrescence full of grubs, and were much surprised to discover, upon dissection, that it was only a diseased growth of the plant, caused (it might be) by the puncture of an insect, but not for the purpose of a nidus or habitation. (J. R.)

Another sort of excrescence is not uncommon on the

terminal shoots of the hawthorn. This is in general irregularly oblong, and the bark which covers it is of an iron colour, similar to the scoriæ of a blacksmith's forge. When dissected, we find no traces of insects, but a hard, ligneous, and rather porous texture. It is not improbable that this excrescence may originate in the natural growth of a shoot being checked by the punctures of aphides, or of those grubs which we have described (page 131).

Many of these excrescences, however, are probably altogether unconnected with insects, and are simply hypertrophic diseases, produced by too much nourishment, like the wens produced on animals. Instances of this may be seen at the roots of the holyhock (*Althea rosea*) of three or four years' standing; on the stems of the elm and other trees, immediately above the root; and on the upper branches of the birch, where a crowded cluster of

Pseudo-galls of the Hawthorn, drawn from specimens.

twigs sometimes grows, bearing no distant resemblance to a rook's nest in miniature, and provincially called witch-knots.

One of the prettiest of these pseudo-galls with which we are acquainted, is produced on the Scotch fir (*Pinus sylvestris*), by the aphis pini, which is one of the largest species of our indigenous aphides. The production we allude to may be found, during the summer months, on the terminal shoots of this tree, in the form of a small cone, much like the fruit of the tree in miniature, but with this difference, that the fruit terminates in a point, whereas the pseudo-gall is nearly globular. Its colour also, instead of being green, is reddish; but it exhibits the tiled scales of the fruit cone.

Pseudo gall produced by *Aphis Pini* on the Scotch fir, drawn from a specimen.

We have mentioned this the more willingly that it seems to confirm the theory which we have hazarded respecting the formation of the bedeguar of the rose and other true galls—by which we ascribed to the sap, diverted from its natural course by insects, a tendency to form leaves, &c., like those of the plant from which it is made to exude.

CHAPTER XX.

Animal Galls,* produced by Breeze-Flies and Snail-Beetles.

The structures which we have hitherto noticed have all been formed of inanimate materials, or at the most of growing vegetables; but those to which we shall now advert are actually composed of the flesh of living animals, and seem to be somewhat akin to the galls already described as formed upon the shoots and leaves of plants. These were first investigated by the accurate Vallisnieri, and subsequently by Réaumur, De Geer, and Linnæus; but the best account which has hitherto been given of them is by our countryman Mr. Bracey Clark, who differs essentially from his predecessors as to the mode in which the eggs are deposited. As, in consequence of the extreme difficulty, if not the impossibility, of personal observation, it is no easy matter to decide between the conflicting opinions, we shall give such of the statements as appear most plausible.

The mother breeze-fly (*Oestrus bovis*, Clark;—*Hypoderma bovis*, Latr.), which produces the tumors in cattle called *wurbles*, or *wormuls* (*quasi*, *worm-holes*), is a two-winged insect, smaller, but similar in appearance and colour to the carder-bee (p. 64), with two black bands, one crossing the shoulders and the other the abdomen, the rest being covered with yellow hair. This fly appears to have been first discovered by Vallisnieri, who has given a curious and interesting history of his observations upon its economy. "After having read

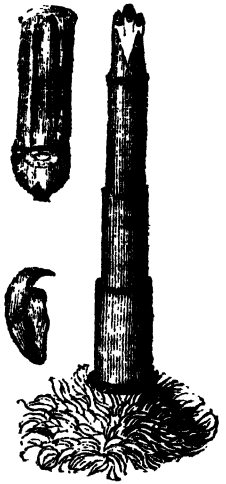
* In order to prevent ambiguity, it is necessary to remark that the excrescences thus called must not be confounded with the true galls, which are occasionally found in the gall-bladder.

this account," says Réaumur, "with sincere pleasure, I became exceedingly desirous of seeing with my own eyes what the Italian naturalist had reported in so erudite and pleasing a manner. I did not then imagine that it would ever be my lot to speak upon a subject which had been treated with so much care and elegance; but since I have enjoyed more favourable opportunities than M. Vallisnieri, it was not difficult for me to investigate some of the circumstances better, and to consider them under a different point of view. It is not indeed very wonderful to discover something new in an object, though it has been already carefully inspected with very good eyes, when we sit down to examine it more narrowly, and in a more favourable position; while it sometimes happens, also, that most indifferent observers have detected what had been previously unnoticed by the most skilful interpreters of nature."*

From the observations made by Réaumur, he concluded that the mother-fly, above described, deposits her eggs in the flesh of the larger animals, for which purpose she is furnished with an ovipositor of singular mechanism. We have seen that the ovipositors of the gall-flies (*Cynips*) are rolled up within the body of the insect somewhat like the spring of a watch, so that they can be thrust out to more than double their apparent length. To effect the same purpose, the ovipositor of the ox-fly lengthens, by a series of sliding tubes, precisely like an opera-glass. There are four of these tubes, as may be seen by pressing the belly of the fly till they come into view. Like other ovipositors of this sort, they are composed of a horny substance; but the terminal piece is very different indeed from the same part in the gall-flies, the tree-hoppers (*Cicadæ*), and the ichneumons, being composed of five points, three of which are longer than the other two, and at first sight not unlike a *fleur-de-lis*, though, upon narrower inspection, they may be discovered to terminate in curved points, somewhat like the claw of a cat. The two shorter pieces are also pointed, but

* Réaumur, Mém. iv. 505.

not curved; and by the union of the five, a tube is composed for the passage of the eggs.



Ovipositor of the Breeze-fly, greatly magnified, with a claw and part of the tube, distinct.

It would be necessary, Réaumur confesses, to see the fly employ this instrument to understand in what manner it acts, though he is disposed to consider it fit for boring through the hides of cattle. "Whenever I have succeeded," he adds, "in seeing these insects at work, they have usually shown that they proceeded quite differently from what I had imagined; but unfortunately I have never been able to see one of them pierce the hide of a cow under my eyes."*

Mr. Bracey Clark, taking another view of the matter, is decidedly of opinion that the fly does not pierce the

* Mém. iv. 538.

skin of cattle with its ovipositor at all, but merely glues its eggs to the hairs, while the grubs, when hatched, eat their way under the skin. If this be the fact, as is not improbable, the three curved pieces of the ovipositor, instead of acting, as Réaumur imagined, like a centre-bit, will only serve to prevent the eggs from falling till they are firmly glued to the hair, the opening formed by the two shorter points permitting this to be effected. This account of the matter is rendered more plausible, from Réaumur's statement that the deposition of the egg is not attended by much pain, unless, as he adds, some very sensible nervous fibres have been wounded. According to this view, we must not estimate the pain produced by the thickness of the instrument; for the sting of a wasp or a bee, although very considerably smaller than the ovipositor of the ox-fly, causes a very pungent pain. It is, in the latter case, the poison infused by the sting, rather than the wound, which occasions the pain; and Vallisnieri is of opinion that the ox-fly emits some acrid matter along with her eggs, but there is no proof of this beyond conjecture.

It ought to be remarked, however, that cattle have very thick hides, which are so far from being acutely sensitive of pain, that in countries where they are put to draw ploughs and waggons, they find a whip ineffectual to drive them, and have to use a goad, in form of an iron needle, at the end of a stick. Were the pain inflicted by the fly very acute, it would find it next to impossible to lay thirty or forty eggs without being killed by the strokes of the ox's tail; for though Vallisnieri supposes that the fly is shrewd enough to choose such places as the tail cannot reach, Réaumur saw a cow repeatedly flap its tail upon a part full of the gall-bumps; and in another instance he saw a heifer beat away a party of common flies from a part where there were seven or eight gall-bumps. He concludes, therefore, with much plausibility, that these two beasts would have treated the ox-flies in the same way, if they had given them pain when depositing their eggs.

The extraordinary effects produced upon cattle, on the

appearance of one of these flies, would certainly lead us to conclude that the pain inflicted is excruciating. Most of our readers may recollect to have seen, in the summer months, a whole herd of cattle start off across a field in full gallop, as if they were racing,—their movements indescribably awkward—their tails being poked out behind them as straight and stiff as a post, and their necks stretched to their utmost length. All this consternation has been known, from the earliest times, to be produced by the fly we are describing. Virgil gives a correct and lively picture of it in his Georgics,* of which the following is a translation, a little varied from Trapp:—

> Round Mount Alburnus, green with shady oaks,
> And in the groves of Silarus, there flies
> An insect pest (named *Œstrus* by the Greeks,
> By us *Asilus*): fierce with jarring hum
> It drives, pursuing, the affrighted herd
> From glade to glade: the air, the woods, the banks
> Of the dried river echo their loud bellowing.

Had we not other instances to adduce, of similar terror caused among sheep, deer, and horses, by insects of the same genus, which are ascertained not to penetrate the skin, we should not have hesitated to conclude that Vallisnieri and Réaumur are right, and Mr. Bracey Clark wrong. In the strictly similar instance of Reindeer fly (*Œstrus tarandi*, Linn.), we have the high authority of Linnæus for the fact, that it lays its eggs *upon* the skin.

"I remarked," he says, "with astonishment how greatly the reindeer are incommoded in hot weather, insomuch that they cannot stand still a minute, no not a moment, without changing their posture, starting, puffing and blowing continually, and all on account of a little

* Est lucos Silari circa ilicibusque virentem
Plurimus Alburnum volitans, cui nomen asilo
Romanum est, Œstrum Graii vertere vocantes,
Asper, acerba sonans; quo tota exterrita silvis
Diffugiunt armenta; furit mugitibus æther
Concussus, sylvæque et sicci ripa Tanagri.
Georg. lib. iii. 146.

fly. Even though amongst a herd of perhaps five hundred reindeer, there were not above ten of those flies, every one of the herd trembled and kept pushing its neighbour about. The fly, meanwhile, was trying every means to get at them; but it no sooner touched any part of their bodies, than they made an immediate effort to shake it off. I caught one of these insects as it was flying along with its tail protruded, which had at its extremity a small linear orifice perfectly white. The tail itself consisted of four or five tubular joints, slipping into each other like a pocket spying-glass, which this fly, like others, has a power of contracting at pleasure."*

In another work he is still more explicit. "This well-known fly," he says, "hovers the whole day over the back of the reindeer, with its tail protruded and a little bent, upon the point of which it holds a small white egg, scarcely so large as a mustard-seed, and when it has placed itself in a perpendicular position, it drops its egg, which rolls down amongst the hair to the skin, where it is hatched by the natural heat and perspiration of the reindeer, and the grub eats its way slowly under the skin, causing a bump as large as an acorn."† The male and female of the reindeer breeze-fly are figured in the 'Library of Entertaining Knowledge, Menageries,' vol. i. p. 405.

There is one circumstance which, though it appears to us to be of some importance in the question, has been either overlooked or misrepresented in books. "While the female fly," say Kirby and Spence, "is performing the operation of oviposition, the animal attempts to lash her off as it does other flies, with its tail;"‡ though this is not only at variance with their own words in the page but one preceding, where they most accurately describe "the herd with their tails in the air, or turned upon their backs, or stiffly stretched out in the direction of the spine,"§ but with the two facts mentioned above from Réaumur, as well as with common observation. If the

* Linnæus, Lachesis Lapponica, July 19th.
† Linnæus, Flora Lapponica, p. 378, ed. Lond. 1792.
‡ Kirby and Spence, Introd. i. 151. § Ibid. p. 149.

ox then do not attempt to lash off the breeze-fly, but runs with its tail stiffly extended, it affords a strong presumption that the fly terrifies him by her buzzing (*asper, acerba sonans*), rather than pains him by piercing his hide; her buzz, like the rattle of the rattle-snake, being instinctively understood, and intended, it may be, to prevent an over-population, by rendering it difficult to deposit the eggs.

The horse breeze-fly (*Gasterophilus equi*, LEACH), which produces the maggots well known by the name of *botts* in horses, is ascertained beyond a doubt to deposit her eggs upon the hair, and as insects of the same genus almost invariably proceed upon similar principles, however much they may vary in minute particulars, it may be inferred with justice, that the breeze-flies which produce galls do the same. The description given by Mr. Bracey Clark, of the proceedings of the horse breeze-fly, is exceedingly interesting.

"When the female has been impregnated, and her eggs sufficiently matured, she seeks among the horses a subject for her purpose, and approaching him on the wing, she carries her body nearly upright in the air, and her tail, which is *lengthened for the purpose*,* curved inwards and upwards: in this way she approaches the part where she designs to deposit the egg; and suspending herself for a few seconds before it, suddenly darts upon it and leaves the egg adhering to the hair; she hardly appears to settle, but merely touches the hair with the egg *held out on the projected point of the abdomen*.* The egg is made to adhere by means of a glutinous liquor secreted with it. She then leaves the horse at a small distance, and prepares a second egg, and poising herself before the part, deposits it in the same way. The liquor dries, and the egg becomes firmly glued to the hair; this is repeated by these flies till four or five hundred eggs are sometimes placed on one horse."

* These circumstances afford, we think, a complete answer to the query of Kirby and Spence—"There can be little doubt (or else what is the use of such an apparatus?) that it bores a hole in the skin."—Introd. i. 162, 2nd edit.

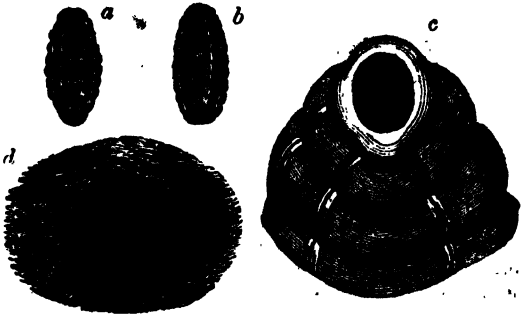
Mr. Clark farther tells us, that the fly is careful to select a part of the skin which the horse can easily reach with his tongue, such as the inside of the knee, or the side and back part of the shoulder. It was at first conjectured, that the horse licks off the eggs thus deposited, and that they are by this means conveyed into its stomach; but Mr. Clark says, "I do not find this to be the case, or at least only by accident; for when they have remained on the hair four or five days, they become ripe, after which time the slightest application of warmth and moisture is sufficient to bring forth, in an instant, the latent larva. At this time, if the tongue of the horse touches the egg, its operculum is thrown open, and a small, active worm is produced, which readily adheres to the moist surface of the tongue, and is thence conveyed with the food to the stomach." He adds, that "a horse which has no ova deposited on him may yet have botts, by performing the friendly office of licking another horse that has."* The irritations produced by common flies (*Anthomyiæ meteoricæ*, Meigen) are alleged as the incitement to licking.

The circumstance, however, of most importance to our purpose, is the agitation and terror produced both by this fly and by another horse breeze-fly (*Gasterophilus hæmorrhoidalis*, Leach), which deposits its eggs upon the lips of the horse, as the sheep-breeze fly (*Œstrus ovis*) does on that of the sheep. The first of these is described by Mr. Clark as "very distressing to the animal, from the excessive titillation it occasions; for he immediately after rubs his mouth against the ground, his fore-feet, or sometimes against a tree, with great emotion; till, finding this mode of defence insufficient, he quits the spot in a rage, and endeavours to avoid it by galloping away to a distant part of the field, and if the fly still continues to follow and teaze him, his last resource is in the water, where the insect is never observed to pursue him. These flies appear sometimes to hide themselves in the grass, and as the horse stoops to

* Linn. Trans. iii. 305.

graze they dart upon the mouth or lips, and are always observed to poise themselves during a few seconds in the air, while the egg is preparing *on the extended point of the abdomen.*"*

The moment the second fly just mentioned touches the nose of a sheep, the animal shakes its head and strikes the ground violently with its fore-feet, and at the same time holding its nose to the earth, it runs away looking about on every side to see if the flies pursue. A sheep will also smell the grass as it goes, lest a fly should be lying in wait, and if one be detected, it runs off in terror. As it will not, like a horse or an ox, take refuge in the water, it has recourse to a rut or dry dusty road, holding its nose close to the ground, thus rendering it difficult for the fly to get at the nostril.

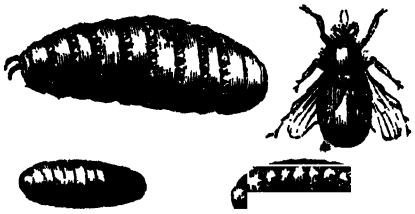


a, The belly of the grub. *b*, Its back. *c*, The tail of the grub, greatly magnified. *d*, The bump, or gall, having its external aperture filled with the tail of the grub.

When the egg of the ox-breeze fly (*Hypoderma bovis*, LATR.) is hatched, it immediately (if Mr. Bracey Clark be correct) burrows into the skin; while, according to

* Linn. Trans. iii. 305.

Réaumur, it is hatched there. At all events, the grub is found in a bump on the animal's back, resembling a gall on a tree,—"a place," says Réaumur, "where food is found in abundance, where it is protected from the weather, where it enjoys at all times an equal degree of warmth, and where it finally attains maturity."* When in an advanced stage, the bumps appear much like the swellings produced upon the forehead by a smart blow. These, with the grubs, are represented in the foregoing figure, and also at page 152.



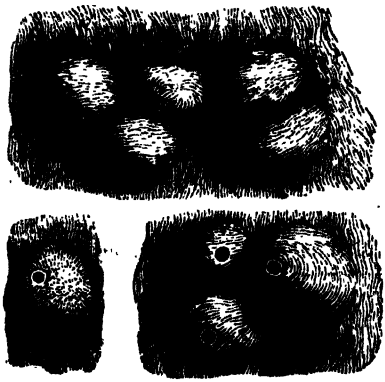
Fly, maggot, and grub of the Ox-breeze fly, with a microscopic view of the maggot.

Every bumb, according to Réaumur, has in its inside a cavity, which is a lodging proportionate to the size of the insect. The bump and cavity also increase in proportion to the growth of the grub. It is not until about the middle of May that these bumps can be seen full grown. Owing to particular circumstances, they do not all attain an equal size. The largest of them are sixteen or seventeen lines in diameter at their base, and about an inch high; but they are scarcely perceptible before the beginning or during the course of the winter.

It is commonly upon young cattle, such, namely, as are two or three years old, that the greatest number of bumps is found; it being rare to observe them upon very

* Mém. iv. 540.

old animals. The fly seems to be well aware that such skins will not oppose too much resistance, and seems to know, also, that tender flesh is the most proper for supplying good nourishment to its progeny. "And why," asks Réaumur, "should not the instinct which conducts it to confide its eggs to the flesh of certain species only, lead it to prefer the flesh of animals of the same species which is most preferable?" The number of bumps which are found upon a beast is equal to the number of eggs which have been deposited in its flesh; or, to speak more correctly, to the number of eggs which have succeeded, for apparently all are not fertile; but this number is very different upon different cattle. Upon one cow only three or four bumps may be observed, while upon another there will appear from thirty to forty. They are not always placed on the same parts, nor arranged in the same manner: commonly, they are near the spine, but sometimes upon or near the thighs and shoulders. Sometimes they are at remote distances from each other; at other times they are so near that



Bumps or wurbles produced on cattle by the Ox-breeze fly.

their circumferences meet. In certain places, three or four tumors may be seen touching each other; and more than a dozen sometimes occur arranged as closely together as possible.

It is very essential to the grub that the hole of the tumor should remain constantly open; for by this aperture a communication with the air necessary for respiration is preserved; and the grub is thence placed in the most favourable position for receiving air. Its spiracles for respiration, like those of many other grubs, are situated immediately upon the posterior extremity of the body. Now being almost always placed in such a situation as to have this part above, or upon a level with the external aperture, it is enabled to respire freely.*

We have not so many examples of galls of this kind as we have of vegetable galls; and when we described the surprising varieties of the latter, we did not perceive that it was essential to the insects inhabiting them to preserve a communication with the external air: in the galls of trees, openings expressly designed or kept free for the admission of air are never observed. Must the grub, then, which inhabits the latter have less need of respiring air than the grub of the breeze-flies in a flesh-gall? Without doubt, not; but the apertures by which the air is admitted to the inhabitants of the woody gall, although they may escape our notice, in consequence of their minuteness, are not, in fact, less real. We know that, however careful we may be in inserting a cork into a glass, the mercury with which it is filled is not sheltered from the action of the air, which weighs upon the cork; we know that the air passes through, and acts upon the mercury in the tube. The air can also, in the same way, penetrate through the obstruction of a gall of wood, though it have no perceptible opening or crack; but the air cannot pass in this manner so readily through the skins and membranes of animals.

In order to see the interior of the cavity of an animal gall, Réaumur opened several, either with a razor or a

* Réaumur, iv. 549.

pair of scissors; the operation, however, cannot fail to be painful to the cow, and consequently renders it impatient under the process. The grub being confined in a tolerably large fistulous ulcer, a part of the cavity must necessarily be filled with pus or matter. The bump is a sort of cautery, which has been opened by the insect, as issues are made by caustic: the grub occupies this issue, and prevents it from closing. If the pus or matter which is in the cavity, and that which is daily added to it, had no means of escaping, each tumor would become a considerable abscess, in which the grub would perish: but the hole of the bump, which admits the entrance of the air, permits the pus or matter to escape; that pus frequently mats the hairs together which are above the small holes, and this drying around the holes acquires a consistency, and forms in the interior of the opening a kind of ring. This matter appears to be the only aliment allowed for the grub, for there is no appearance that it lives, like the grubs of flesh-flies, upon putrescent meat. Mandibles, indeed, similar to those with which other grubs break their food, are altogether wanting. A beast which has thirty, forty, or more of these bumps upon its back, would be in a condition of great pain and suffering, terrible indeed in the extreme, if its flesh were torn and devoured by as many large grubs; but there is every appearance that they do not at all afflict, or only afflict it with little pain. For this reason cattle most covered with bumps are not considered by the farmer as injured by the presence of the fly, which generally selects those in the best condition.

A fly, evidently of the same family with the preceding, is described in Bruce's 'Travels,' under the name of zimb, as burrowing during its grub state in the hides of the elephant, the rhinoceros, the camel, and cattle. "It resembles," he says, "the gad-fly in England, its motion being more sudden and rapid than that of a bee. There is something peculiar in the sound or buzzing of this insect; it is a jarring noise together with a humming, which as soon as it is heard all the cattle forsake their food and run wildly about the plain, till they die,

worn out with fatigue, fright, and hunger. I have found," he adds, "some of these tubercles upon almost every elephant and rhinoceros that I have seen, and attribute them to this cause. When the camel is attacked by this fly, his body, head, and legs break out in to large bosses, which swell, break, and putrefy, to the certain destruction of the creature."* That camels die under such symptoms, we do not doubt; but we should not, without more minutely accurate observation, trace all this to the breeze-fly.

MM. Humboldt and Bonpland discovered, in South America, a species, probably of the same genus, which attacks man himself. The perfect insect is about the size of our common house-fly (*Musca domestica*), and the bump formed by the grub, which is usually on the belly, is similar to that caused by the ox breeze-fly. It requires six months to come to maturity, and if it is irritated it eats deeper into the flesh, sometimes causing fatal inflammations.

Grub Parasite in the Snail.

During the summer of 1829, we discovered in the hole of a garden-post, at Blackheath, one of the larger grey snail shells (*Helix aspersa*, Muller), with three white soft-bodied grubs burrowing in the body of the snail. They evidently, from their appearance, belonged to some species of beetle, and we carefully preserved them in order to watch their economy. It appeared to us that they had attacked the snail in its stronghold, while it was laid up torpid for the winter; for more than half of the body was already devoured. They constructed for themselves little cells attached to the inside of the shell and composed of a sort of fibrous matter, having no distant resemblance to shag tobacco, both in form and smell, and which could be nothing else than the remains of the snail's body. Soon after we took them, appearing to have devoured all that remained of the poor snail,

* Bruce's Travels, i. 5, and v. 191.

we furnished them with another, which they devoured in the same manner. They formed a cocoon of the same fibrous materials during the autumn, and in the end of October appeared in their perfect form, turning out to be the *Drilus flavescens*, the grub of which was first discovered in France in 1824. The time of their appearance, it may be remarked, coincides with the period when snails become torpid. (J. R.)

In the following autumn, we found a shell of the same species with a small pupa-shaped egg deposited on the lid. From this a caterpillar was hatched which subsequently devoured the snail, spun a cocoon within the shell, and was transformed into a small moth (of which we have not ascertained the species) in the spring of 1830.

END OF INSECT ARCHITECTURE.

MISCELLANIES.

I.—ON THE RAVAGES OF INSECTS.

Voracity of Caterpillars, Grubs, and Maggots.

INSECTS, in the early stage of their existence, may be compared to an Indian hunter, who issues from his hut, as they do from the egg, with a keen appetite. As soon as he is successful in finding game, he gorges himself till he can eat no more, and then laying him down to sleep, only bestirs himself again to go through a similar process of gorging and sleeping; just so the larvæ of insects doze away a day or more when casting their skins, and then make up for their long fast by eating with scarcely a pause. Professor Bradley calculates (though upon data somewhat questionable) that a pair of sparrows carry to their young about three thousand caterpillars in a week;* but this is nothing when compared with the voracity of caterpillars. Of the latter we have more accurate calculations than that of Bradley, who multiplied the number of caterpillars which he observed taken in one hour by the hours of sunlight in a week. Redi ascertained by experiment that the maggot of the common blow-fly (*Musca carnaria*) becomes from 140 to 200 times heavier within twenty-four hours;† and the cultivators of silk-worms know the exact quantities of leaves which their broods devour. "The result," says Count Dandolo, "of the most exact calculations is, that the quantity of leaves drawn from the tree employed for each ounce of

* Account of the Works of Nature.
† Esperienze de Insetti, p. 23.

eggs amounts to 1609 lbs. 8 oz., divided in the following manner:"—

	Sorted leaves. lbs.	oz.	Refuse. lbs.	oz.
First age	6	0	1	8
Second age	18	0	3	0
Third age	60	0	9	0
Fourth age	180	0	27	0
Fifth age	1098	0	102	0
Per ounce of eggs of sorted leaves . lbs.	1362	0	142	8
Refuse	142	8		
Lost from the leaves by evaporation, &c.	105	0		
	1609	8		

He adds to this curious table, that from the 1362 lbs. of sorted leaves given to the caterpillars, it is necessary to deduct 155 lbs. 7 oz. 4 drs. of litter, consisting of fragments of uneaten leaves, stalks, fruit, &c., and consequently that they actually devour only 1206 lbs. 4 oz. 4 drs. It is necessary also to mention that of this quantity 745 lbs. 8 oz. of dung are carried from the hurdles; and consequently there is only digested 771 lbs. 7 oz. 4 drs. of pure leaves, which produce 120 lbs. of silk cocoons,—giving a loss by evaporation from the worms in gas and vapour of 496 lbs. 4 oz., nearly three parts of this loss occurring in the six last days of the fifth age.* These deductions, however, do not affect the amount eaten by the caterpillars produced from 1 oz. of eggs, which is upwards of 1200 lbs. A single silk-worm, as we before mentioned, consumes within thirty days about 60,000 times its primitive weight.

When we take these facts into consideration, we need not be surprised at the extensive ravages committed by other caterpillars, many of which are much larger than the silk-worm, and all of them produced in broods of considerable numbers. Mr. Stephens, in his valuable catalogue of British insects, a work of very extraordinary

* Count Dandolo's Art of rearing Silk-Worms, p. 322-24, Eng. Transl.

accuracy, enumerates nearly 2000 species of native moths and butterflies; and as the females of these are for the most part very prolific, we have little reason to be surprised at the occasional extent of their depredations. The 2000 species just mentioned are, besides, not more than a fifth of our native insects, most of the grubs and maggots of which are exceedingly voracious and destructive.

It appears to be indispensable for most insects to feed copiously during their larva state, in order to supply a store of nutriment for their subsequent changes; for many of them eat nothing, and most of them little, after they have been transformed into pupæ and perfect insects. What is no less wonderful, a corresponding change takes place in the internal formation of their organs of digestion. A caterpillar will, as we have seen, devour in a month 60,000 times its own weight of leaves, while the moth or the butterfly into which it is afterwards transformed may not sip a thousandth part of its weight of honey during its whole existence. Now, in the caterpillar, nature has provided a most capacious stomach, which, indeed, fills a very large portion of its body; but in the butterfly the stomach is diminished to a thread. By a series of minute dissections, conducted with great skill, Heroldt traced these changes, as they successively occur, from the caterpillar to the butterfly. In the caterpillar he found the gullet, the honey-stomach, the true stomach, and the intestines capacious. Two days after its first change all these are visibly diminished, as well as the silk reservoirs, which, in a chrysalis eight days old, have wholly disappeared; while the base of the gullet is dilated into a crop, and the stomach still more contracted into a spindle form. When near its change into the perfect insect the gullet is still more drawn out, while the crop, still small, is now on one side of the gullet; and in the butterfly is enlarged into a honey-stomach.

It is remarkable that in men of such extraordinary appetite as amounts to a disease (*Bulimia*, Cullen), the natural capacity of the stomach, which, according to Blumenbach, contains about three pints,* is very much

* Blumenbach, Physiol., s. xxiii.

View of the upper side.

View of the under side.

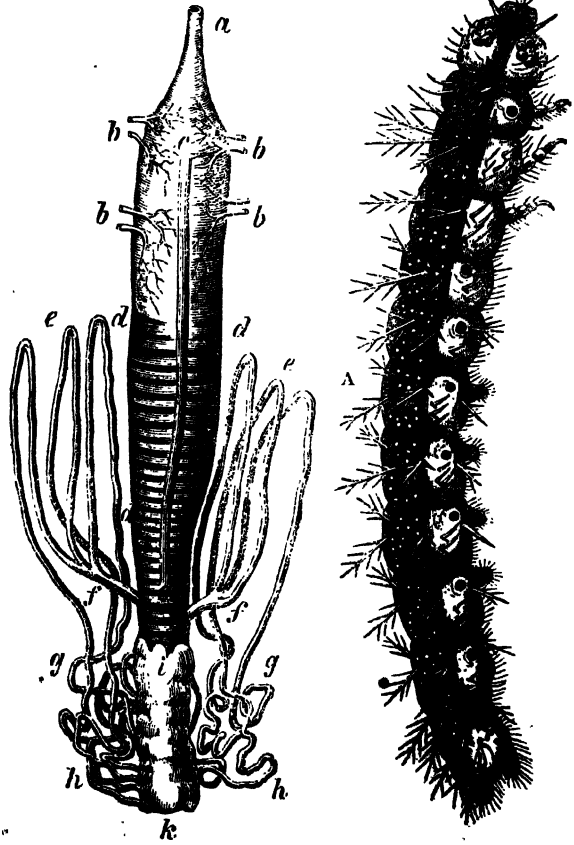
A, B, C, The œsophagus and its appendages.

D, E, The stomach;—a pair of muscles wind spirally round it, and by their contraction squeeze the digested food into the intestines.

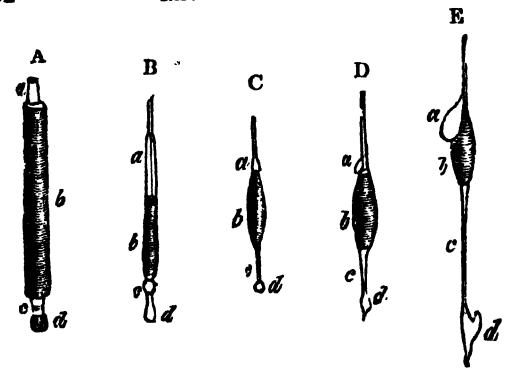
E, F, The first large intestine. F, G, the second. G, H, the third.

I, I, The biliary tubes, or bile vessels.

Viscera of the Cossus.



A, Caterpillar of Vanessa urticæ magnified. *a*—*k*, the intestines of the same. *a*, the gullet. *b b b b*, pulmonary tubes. *c c*, ligament of the stomach. *d d d d*, transparent rings of the same. *e e*, *f*, *g g*, *h h*, biliary vessels. *i k*, the rectum.



Intestinal canals of the caterpillar, pupa, and butterfly.

A. Caterpillar. *a*, the œsophagus. *b*, the stomach. *c d*, the two large intestines.

B. Pupa *two* days old. *a*, the œsophagus. *b*, the stomach. *c d*, the two large intestines.

C. Pupa *eight* days old. *a*, dilation of the œsophagus, forming the *crop* or *honey-stomach*.

D. Pupa immediately before its transformation. *a*, the honey-stomach become a lateral appendage of the œsophagus. *b*, the stomach. *c d*, the large intestines.

E. Butterfly. *a*, honey-stomach. *b*, the digesting stomach. *c d*, the large intestines, become very long.

enlarged. This was peculiarly the case with Tarare, an Italian juggler, who, from swallowing flints, whole baskets of fruit, &c., seems to have enlarged the capacity of his stomach so as to render his appetite insatiable. M. Tessier, of the Infirmary at Versailles, where Tarare died of consumption, found on examination that his stomach was prodigiously distended.* The same must have been the case with the French prisoner at Liverpool, who, on the testimony of Dr. Cochrane, consumed, in one day, sixteen pounds of raw meat and tallow candles, besides five bottles of porter.†

The mandibles of caterpillars, which do not act per-

* M. Percy, in Rapport d'Institute Nationelle.

† Med. and Phys. Journ., iii. 209.

pendicularly like the jaws of quadrupeds, but horizontally, are for the most part very sharp and strong, being of a hard, horny substance, and moved by powerful muscles. They are, for the most part, slightly bent in the form of a reaping-hook; having the concavity indented with tooth-shaped projections, formed out of the substance of the jaw, and not socketed as the teeth of quadrupeds. These are made to meet like the blades of a pair of pincers; and in some cases they both chop and grind the food.* Besides these there is a pair of jaws (*maxillæ*) placed on each side of the middle portion of the under lip; and from their being of a softer substance they seem to be more for the purpose of retaining the food than for mastication. This formidable apparatus for masticating (*Trophi*) is well adapted to supply the large demands of the capacious stomachs of larvæ; and when we consider that all of them are employed in eating at least for ten or twelve hours in the day, and a great number during the night, we need not wonder at their extensive ravages upon the substances on which they feed. It may be interesting, however, to give a few examples of their destructiveness; and with this view it will be convenient to consider them under the three popular names of caterpillars, grubs, and maggots.

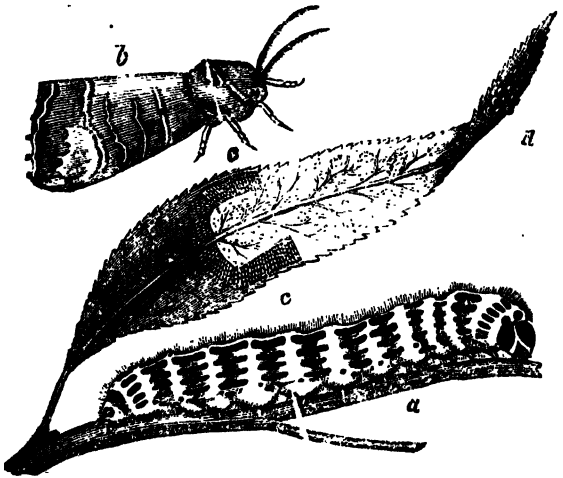
Caterpillars.

The ravages of caterpillars are amongst the most conspicuous of insect depredations, in consequence of their being committed upon the leaves of trees, bushes, and plants, which are often stripped as bare as in winter. Even the smaller sorts of caterpillars become, from their multiplicity, sometimes as destructive as those which are of considerable magnitude. During the summer of 1827 we were told that an extraordinary *blight* had suddenly destroyed the leaves of all the trees in Oak of Honour Wood, Kent. On going thither, we found the report had been little exaggerated; for though it was "in the leafy month of June," there was scarcely a leaf to be

* Cuvier, Anat. Com., iii. 322.

seen on the oak-trees, which constitute the greater portion of the wood. But we were rather surprised when we discovered, on examination, that this extensive destruction had been effected by one of the small solitary leaf-rollers (*Tortrix viridana*, HAWORTH); for one of this sort seldom consumes more than four or five leaves, if so much, during its existence. The number, therefore, of these caterpillars must have been almost beyond conception; and that of the moths, the previous year, must also have been very great: for the mother moth only lays from fifty to a hundred eggs, which are glued to an oak branch, and remain during the winter. It is remarkable that in this wood during the two following summers these caterpillars did not abound. (J. R.)

Instances like this, however, from solitary species, are,



Ravages of the buff-tip caterpillar (*Pygæra bucephala*). *a*, the full-grown caterpillar. *b*, the moth. *c c*, a line of young caterpillars, advancing along a leaf and devouring it half through as they march *d*, the eggs.

we believe, less common than those of the ravages of gregarious caterpillars. In 1826, colonies of the buff-tip (*Pygæra bucephala*, Ochsenheim) were in some parts of the country very abundant. We remarked them particularly at Harrow-on-the-Hill, and at Compton-Basset in Wiltshire. From their feeding in company, they strip a tree, branch after branch, scarcely leaving the fragment of a leaf, till a great portion of it is completely bare. Some of the magnificent beeches in Compton Park, from this cause, appeared with the one-half of their branches leafless and naked, while the other half was untouched. Besides the beech, these caterpillars feed on the oak, the lime, the hazel, the elm, and the willow. When newly hatched they may be readily discovered, from their singular manner of marshalling themselves, like a file of soldiers, on a single leaf, only eating it half through; and in their more advanced stage, their gaudy stripes of yellow and black render them very conspicuous on the branches which they have nearly stripped bare. The cuckoo feeds as greedily upon them as they do on leaves, and may be seen early in the morning perched in the midst of their colonies, and devouring them by dozens. (J. R.)

Those caterpillars which feed upon fruit-trees and hedge shrubs are still more likely to attract attention; since, when any of these are abundant, it is scarcely possible to stir out of doors without observing them. Thus, in the suburbs of London, in the summer of 1829, not only the orchards and gardens, but every hedge, swarmed with the lackey caterpillars (*Clisiocampa neustria*), which are what naturalists term *polyphagous* feeders, that is, they do not confine themselves to a particular sort of tree, but relish a great number. The hawthorn, the blackthorn, and the oak, however, seem to be most to their taste; while they are rare on the willow, and we have never observed them on the poplar or the elder.

Another of what may be appropriately termed the encamping caterpillars, of a much smaller size, and of a different genus, is the small ermine (*Yponomeuta padella*), which does not, besides, feed quite so indiscriminately; but when the bird-cherry (*Prunus padus*), its

peculiar food, is not to be had, it will put up with black-thorn, plum-tree, hawthorn, and almost any sort of orchard fruit-tree. With respect to such caterpillars as feed on different plants, Réaumur and De Geer make the singular remark, that in most cases they would only eat the sort of plant upon which they were originally hatched.* We verified this, in the case of the caterpillar in question, upon two different nests which we took, in 1806, from the bird-cherry at Crawfordland, in Ayrshire. Upon bringing these to Kilmarnock, we could not readily supply them with the leaves of this tree; and having then only a slight acquaintance with the habits of insects, and imagining they would eat any sort of leaf, we tried them with almost everything green in the vicinity

Encampment of the caterpillar of the small ermine (*Yponomeuta padella*) on the Siberian crab.

* De Geer, Mém. i. 319.

of the town; but they refused to touch any which we offered them. After they had fasted several days, we at length procured some fresh branches of the bird-cherry, with which they gorged themselves so that most of them died. Last summer (1829) we again tried a colony of these caterpillars, found on a seedling plum-tree at Lee, in Kent, with blackthorn, hawthorn, and many other leaves, and even with those of the bird-cherry; but they would touch nothing except the seedling plum, refusing the grafted varieties. (J. R.)

A circumstance not a little remarkable in so very nice a feeder is, that in some cases the mother moth will deposit her eggs upon trees not of indigenous growth, and not even of the same genus with her usual favourites. Thus, in 1825, the cherry-apple, or Siberian crab (*Pyrus prunifolia*, WILLDENOW), so commonly grown in the suburbs of London, swarmed with them. On a single tree at Islington we counted above twenty nests, each of which would contain from fifty to a hundred caterpillars; and though these do not grow thicker than a crow-quill, so many of them scarcely left a leaf undevoured, and, of course, the fruit, which showed abundantly in spring, never came to maturity. The summer following they were still more abundant on the hawthorn hedges, particularly near the Thames, by Battersea and Richmond. Since then we have only seen them sparingly; and last summer we could only find the single nest upon which we tried the preceding experiment. (J. R.) This present spring (1830) they have again appeared in millions on the hedges.

Réaumur says that in some years they were exceedingly destructive to his apple-trees, though they did not touch his pears, plums, or apricots,* which agrees precisely with our own remarks. We are well aware that there are several species of the small ermines, all similar in manners, such as the one which feeds on the spindle-tree (*Euonymus*), and produces the prettiest moth of the genus (*Yponomeuta Euonymella*); but our preceding remarks all apply to one species.

* Réaumur, Mém. ii. 198.

In 1829 we remarked a very extraordinary number of webs of some similar caterpillar, of which we did not ascertain the species, on the willows in Holland and the Netherlands, from Amsterdam to Ostend. In some districts, particularly near Bruges and Rotterdam, the leaves were literally stripped from whole rows of trees; while other rows, at no considerable distance, were entirely free from their ravages. A foreign naturalist, quoted by Harris in his Aurelian, says, that the caterpillar of the Camberwell beauty (*Vanessa Antiopa*), which feeds gregariously on the willow, sometimes defoliates the trees of a whole district in the Low Countries; but the ravages observed by us were evidently made by the caterpillars of some small moth. (J. R.)

None of the preceding details, however, appear so striking as what is recorded of the brown-tail moth (*Porthesia auriflua*) by Mr. W. Curtis,* whose multitudinous colonies spread great alarm over the country in the summer of 1782. This alarm was much increased by the exaggeration and ignorant details which found their way into the newspapers. The actual numbers of these caterpillars must have been immense, since Curtis says, "in many of the parishes near London subscriptions have been opened, and the poor people employed to cut off the webs at one shilling per bushel, which have been burnt under the inspection of the churchwardens, overseers, or beadle of the parish: at the first onset of this business fourscore bushels, as I was most credibly informed, were collected in one day in the parish of Clapham."

It is not, therefore, very much to be wondered at, that the ignorant, who are so prone to become the victim of groundless fears, should have taken serious alarm on having so unusual a phenomenon forced upon their attention. Some alarmists accordingly asserted that the caterpillars "were the usual presage of the plague;" and others that they not only presaged it, but would actually cause it, for "their numbers were

* Curtis, Hist. of Brown-tail Moth, 4to. London, 1782.

great enough to render the air pestilential;" while, to add to the mischief, "they would destroy every kind of vegetation, and starve the cattle in the fields." "Almost every one," adds Curtis, "ignorant of their history, was under the greatest apprehensions concerning them; so that even prayers were offered up in some churches to deliver the country from the apprehended approaching calamity."

It seems to have been either the same caterpillar, or one very nearly allied to it, probably that of the golden-tail (*Porthesia Chrysorrhœa*), which in 1731-2 produced a similar alarm in France. Réaumur, on going from Paris to Tours, in September 1730, found every oak, great and small, literally swarming with them, and their leaves parched and brown as if some burning wind had passed over them; for when newly hatched, like the young buff-tips, they only eat one of the membranes of the leaf, and of course the other withers away. These infant legions, under the shelter of their warm nests, survived the winter in such numbers, that they threatened the destruction not only of the fruit-trees, but of the forests,—every tree, as Réaumur says, being overrun with them. The Parliament of Paris thought that ravages so widely extended loudly called for their interference, and they accordingly issued an edict, to compel the people to uncaterpillar (*décheniller*) the trees; which Réaumur ridiculed as impracticable, at least in the forests. About the middle of May, however, a succession of cold rains produced so much mortality among the caterpillars, that the people were happily released from the edict; for it soon became difficult to find a single individual of the species.* In the same way the cold rains, during the summer of 1829, seem to have nearly annihilated the lackeys, which in the early part of the summer swarmed on every hedge around London. The ignorance displayed in France at the time in question, was not inferior to that recorded by Curtis; for the French journalists gravely asserted that part of the caterpillars were pro-

* Réaumur, ii. p. 137.

duced by spiders; and that these spiders, and not the caterpillars, constructed the webs of the slime of snails, which they were said to have been seen collecting for the purpose! "Verily," exclaims Réaumur, "there is more ignorance in our age than one might believe."

It is justly remarked by Curtis, that the caterpillar of the brown-tail moth is not so limited a feeder as some, nor so indiscriminate as others; but that it always confines itself to trees or shrubs, and is never found on herbaceous plants, whose low growth would seldom supply a suitable foundation for its web. Hence the absurdity of supposing it would attack the herbage of the field, and produce a famine among cattle. Curtis says, it is found on the "hawthorn most plentifully, oak the same, elm very plentifully, most fruit-trees the same, black-thorn plentifully, rose-trees the same, bramble the same, on the willow and poplar scarce. None have been noticed on the elder, walnut, ash, fir, or herbaceous plants. With respect to fruit-trees the injuries they sustain are most serious, as, in destroying the blossoms as yet in the bud, they also destroy the fruit in embryo; the owners of orchards, therefore, have great reason to be alarmed."

The sudden appearance of great numbers of these caterpillars in particular years, and their scarcity in others, is in some degree explained by a fact stated by Mr. Salisbury. "A gentleman of Chelsea," he says, "has informed me that he once took a nest of moths and bred them; that some of the eggs came the first year, some the second, and others of the same nest did not hatch till the third season."* We reared, during 1829, several nests both of the brown-tails and of the golden-tails, and a number of the females deposited their eggs in our nurse-cages; but, contrary to the experiment just quoted, all of these were hatched during the same autumn. (J. R.) The difference of temperature and moisture in particular seasons may produce this diversity.

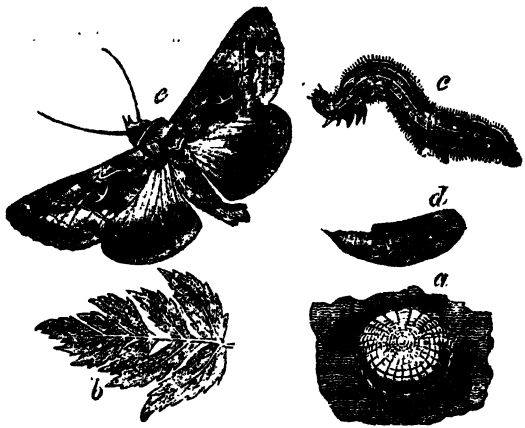
An alarm, similar to those we have recorded, was produced in France in 1735 by the green-striped caterpillars.

* Salisbury, Hints on Orchards, p. 53.

of a moth very common in Britain, called by collectors, from a mark on its upper wings, the Y, or more properly the *γ* moth (*Plusia Gamma*, Ochs.). Though ranked in some classifications amongst the nocturnal moths, it flies chiefly by day, and may be seen in Battersea-fields, or other moist meadows, flitting from herb to herb and flower to flower, in short and low flights; for it seldom soars higher than the tallest grass-stem, or the crimson flower-heads of the knap-weed, upon whose honey it sometimes regales, remaining on the wing all the while it is sipping it. During the cold rainy summer of 1829 it was almost the only moth which appeared plentiful. (J. R.) At least two broods seem to be produced during the season; which may account for its being found from May till the setting-in of the winter frosts.

Notwithstanding its being so plentiful, however, we have not heard of its having ever been so destructive here as in France, where, as usual, the most improbable causes were assigned for its increase. "In some places," says Réaumur, "they assured me they had seen an old soldier throw the spell; and in other places an ugly and mischievous old woman had wrought all the evil."* These supposed supernatural agents, however, must have been either very numerous or very active to fill, not only the gardens, but every field, with legions of those caterpillars, which devoured almost every green thing, and left only the stalks as monuments of their devastation. The alarm proceeded farther, for it began to be whispered that they were poisonous; and many were in consequence afraid to touch soups or salads. Réaumur thought it incumbent on him to refute this notion at some length; but we cannot accept his doctrine as very palatable, when he tells us that few dishes of soup or salad are *ever* prepared without containing caterpillars, and yet all the world are not poisoned thereby, any more than by eating oysters or viper broth. He endeavoured also to account by calculation for their excess, from the data of the female moth laying about four hundred eggs. Now, if there

* Réaumur, ii. 336.



Transformations of the γ moth (*Plusia Gamma*). *a*, the egg, greatly magnified, on a morsel of leaf. *b*, the egg on a leaf, natural size. *c*, the larva. *d*, the pupa. *e*, the moth.

were only twenty caterpillars distributed in a garden, and all lived through the winter, and became moths in the succeeding May, the eggs laid by these, if all fertile, would produce 800,000, a number much more than sufficient to effect great destruction.* Did not Providence, therefore, put causes in operation to keep them in due bounds, the caterpillars of this moth alone, leaving out of consideration the 2000 other British species, would soon destroy more than half of our vegetation.

The caterpillar just mentioned, amongst other pot-herbs, attacks coleworts and cabbage; and may sometimes be found there along with another, not uncommon, but seldom very destructive, called by collectors the burnished brass (*Plusia chrysitis*), which differs little from the caterpillar of the γ moth, except in being of a brighter green. Another, called the old gentlewoman (*Mamestra brassicæ*, TREITSCHE), is so destructive to cabbages in Germany, that the gardeners gather whole basketsful

* Réaumur, ii. 337.

and bury them; but as Rösel remarks, they might as well endeavour to kill a crab by covering it with sea-water, for it is natural to them to burrow under ground when they change into chrysalides.* We have seen this caterpillar, as well as that of the brown-eye (*Mamestra oleracea*), do considerable damage in Wiltshire, but nothing to what is reported of it in Germany.

The leaves of cabbages, cauliflower, brocoli, colewarts, and turnips, are frequently devoured to a more considerable extent by the sub-gregarious caterpillars of the white butterflies (*Pontia brassicæ*, *P. napi*, &c.). From the great multiplicity of the butterflies, indeed, and from there being two broods in the year, we have reason to wonder that their ravages are not more extensive. But we have remarked that they seem more partial to wild than cultivated plants; for we have seen, near Islington, the oleraceous weeds, such as rape (*Brassica napus*), overrun with them in the very same fields with cultivated cabbages, which were not touched (J. R.); so that the caterpillars are not always so injurious as we might at first suppose, since in this case they tend to keep down the weeds, while the birds and the ichneumon flies keep them in check by making prey of them.

The gregarious caterpillars of an allied species, called the black-veined white butterfly (*Pieris Cratægi*, Stephens), is in some seasons and districts no less destructive to orchards and hawthorn hedges than the preceding ones are to the kitchen-garden. Salisbury, who wrote at Chelsea in 1815, says it "commits great destruction every spring, and not only to the apple-trees, but other kinds of fruits."† Mr. Stephens, writing in 1827, says, "In June, 1810, I saw it in plenty at Coombe Wood, and in the following year I captured several at Muswell-hill, since which time I have not seen any at large."‡ Mr. Haworth also says, "it has not of late years been seen at Chelsea, where it formerly abounded."

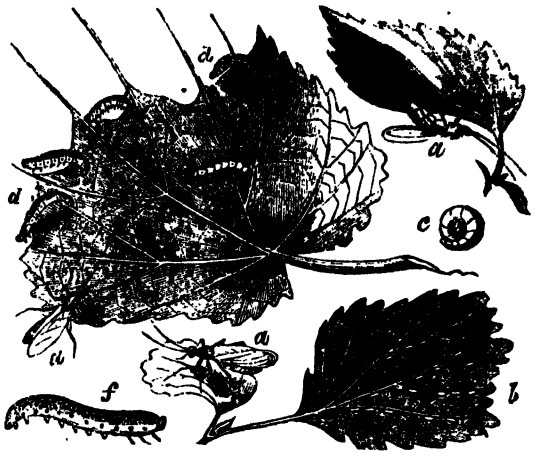
* Rösel, Inseckten, i. iv. 170.
† Hints on Orchards, p. 56.
‡ Illustrations, i. Haustellata, 27.

We have never met with it at all. According to Salisbury the female butterfly lays her eggs near the extremity of an old rather than a young branch, and covers them with a coating of gluten, which is both impervious to moisture and impenetrable (this we doubt) to the bills of birds. "In this state," he adds, "we have instances of their remaining without losing their vitality for several years, until a favourable opportunity of their being brought into existence arrives."* The caterpillars, which are at first black and hairy, live in common in a silken tent. They become subsequently striped with reddish brown, and disperse over the trees. This caterpillar and its butterfly are figured in a subsequent page.

Our gooseberry and red-currant bushes are very frequently despoiled of their leaves, both by the speckled caterpillar of the magpie moth (*Abraxas grossulariata*), and by what Réaumur terms the pseudo-caterpillars of one of the saw-flies (*Nematus Ribesii*, Stephens). The latter insect has a flat yellow body and four pellucid wings, the two outer ones marked with brown on the edge. In April it issues from the pupa, which has lain under ground from the preceding September. The female of the gooseberry saw-fly does not, like some of the family, cut a groove in the branch to deposit her eggs;—"of what use, then," asks Réaumur, "is her ovipositor saw?"† In order to satisfy himself on this point, he introduced a pair of the flies under a bell-glass along with a branch bent from a red-currant bush, that he might watch the process. The female immediately perambulated the leaves in search of a place suited to her purpose, and passing under a leaf began to lay, depositing six eggs within a quarter of an hour. Each time she placed herself as if she wished to cut into the leaf with her saw; but, upon taking out the leaf, the eggs appeared rather projecting than lodged in its substance. They adhered so firmly, however, that they could not be detached without crushing them. He could not discover

* Hints on Orchards, p. 57.

† See chap. vii. for a description of this curious instrument.



a a a, Saw-fly of the gooseberry (*Nematus Ribesii*, STEPHENS). *b*, its eggs on the nervures of a leaf. *d d*, the caterpillars eating. *c*, one rolled up. *f*, one extended.

any groove ;* but we think it likely that a minute cut is made in the exterior membrane of the leaf, the edges of which grasp and hold firm the part of the egg which is thrust into it by the insect. Be this as it may, the caterpillars are hatched in two or three weeks; and they feed in company till after midsummer, frequently stripping both the leaves and fruit of an extensive plantation. The caterpillar has six legs and sixteen prolegs, and is of a green colour mixed with yellow, and covered with minute black dots raised like shagreen. In its last skin it loses the black dots and becomes smooth and yellowish white. The Caledonian Horticultural Society have published a number of plans for destroying these caterpillars.

An allied species of saw-fly (*Nematus Capreæ*,

* Réaumur, v. 125.

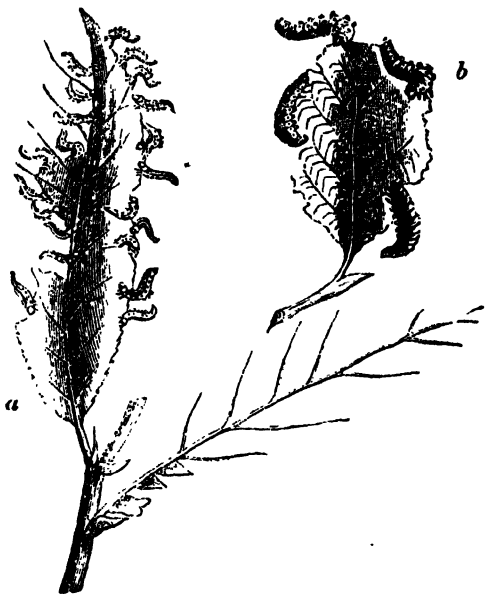
Stephens) frequently becomes extensively destructive to several species of willow, sallow, and osier. It is so like that of the gooseberry and that of the willow *(Nematus salicis)*, which is not British, that it has been confounded with these by Fabricius, Stewart, Gmelin, and other authors. In the summer of 1828, we observed a considerable group of young standards of the golden osier *(Salix vitellina)*, in a nursery at Lewisham, rendered quite leafless by these caterpillars; which, when feeding, throw themselves into singular postures by holding only with their fore feet. The fly appears in spring, and places its eggs in a round patch on the back of the leaf, and not along the nervures, like the gooseberry saw-fly. During the three last summers, we also remarked that the alders *(Alnus glutinosa)* along the banks of the Ravensbourne, in Kent, were extensively stripped of their leaves by a saw-fly caterpillar, very like the preceding, but of a larger size. (J.R.) It appears to be the same as one figured by Réaumur* *(Selandria Alni?* Stephens).

Another slimy caterpillar of a saw-fly, allied to that of the cherry *(Tenthredo Cerasi)*, is called the slug-worm in North America, where it has increased so numerously as to threaten the entire destruction of fruit-trees, including the cherry, plum, pear, and quince. Where they are numerous, the air becomes loaded with a disagreeable and sickly effluvium. The history of this orchard pest has been admirably written by Professor Peck.†

When a turnip crop has been fortunate enough to escape the ravages committed on it in the seed leaf by a small jumping beetle *(Haltica nemorum*, Illiger), and by a root weevil *(Nedyus contractus*, Stephens), a no less formidable depredator sometimes appears in a caterpillar belonging to the saw-fly family *(Tenthredinidæ)*, and apparently of the genus *Athalia*. An instance is recorded by Marshall, in the Philosophical Transactions,

* Réaumur, vol. v., pl. 11, fig. 1, 2.

† Nat. Hist. of the Slug-Worm, Boston, 1799.



a, Nematus capreæ, on the osier; *b, Selandria alni?* on the alder.

of many thousand acres having had to be ploughed up on account of the devastations caused by these insects. It is, he informs us, the general opinion in Norfolk that they come from over-sea; and a farmer averred that he saw them arrive in clouds so as to darken the air, while the fishermen reported that they had repeatedly witnessed flights of them pass over their heads when they were at a distance from land. On the beach and the cliffs, indeed, they lay in heaps, so that they might have been taken up with shovels; while three miles inland they crowded together like a swarm of bees.*

* Phil. Trans. vol. lxxiii. p. 317.

We have little doubt, however, that these details are put in an inverse order; as frequently occurs in histories of the proceedings of insects by those but little acquainted with their habits. Insects of this family, indeed, seldom fly far, and could not at all events cross the sea, unless it might be a narrow bay or inlet; and if they had, we ought to have heard of their departure as well as their arrival, since their extraordinary number could not have failed to attract public notice on other shores. The nature of these insects is to lie in the pupa state during the winter under ground; and when, at its appointed time, the fly comes forth, it only lives to lay its eggs, usually dying within a few days or weeks. It must have been, therefore, after the laying their eggs on the turnips, and not before, that clouds of the flies were seen at sea and on the shore, though not arriving, but going away. They were, doubtless, impelled by that restless desire of change felt by all animals when death is approaching, and which in tropical countries is yearly exemplified in the destruction of locusts, for these always make for the sea, and perish there. But though they were thus got rid of in August, 1782, they left a progeny behind them in the black caterpillars which were hatched from their eggs. In the summer of 1783, accordingly, we are told by Mr. Marshall, that whole districts were ravaged by them,—the descendants, of course, in the second generation, of the saw-flies which perished on the beach and at sea the preceding autumn.

Some caterpillars, which either conceal themselves under ground, or feed on roots and the wood of trees, do considerable injury, without apparent cause; and often give occasion to the popular notions respecting mysterious blights. In this manner will the caterpillars of the ghost moth *(Hepialus Humuli)* gnaw the roots of the burdock, and, what is of more consequence, of the hop plant; till the shoots are weakened, and the leaves droop in bright sunshine. We have repeatedly seen, in the gardens about Lee, a large branch of the red-currant bush, though previously healthy and loaded with fruit, all of a sudden droop and wither, giving good cause to

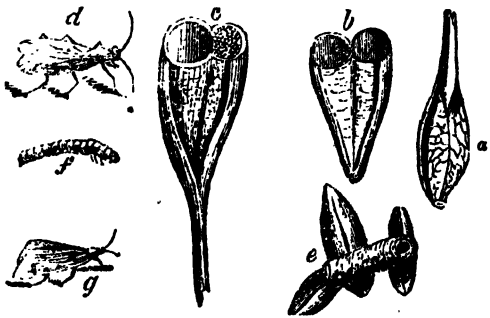
surmise, except in the leaves not being brown or parched, that it had been struck with lightning. On cutting into such branches, however, the cause was uniformly found to be the ravages of the caterpillar of the currant hawk-moth (*Ægeria tipuliformis*, STEPHENS), which abounds in the vicinity. But we have also remarked that it only occasionally produces this effect upon the trees; for several bushes upon which we have found old pupa-cases projecting from the bark, remained healthy and uninjured. (J.R.) Sir Joseph Banks showed Mr. Kirby a currant branch perforated by this caterpillar to the pith, and said the size of the fruit was in consequence diminished.* In Germany it is reported to destroy even large bushes of the red currant. There can be no doubt that the caterpillars of the goat-moth frequently destroy willow, poplar, and oak trees, of considerable magnitude; but the mother moth seems to prefer laying her eggs upon those which have already begun to decay. A black poplar tree, not thicker than a man's leg, and stripped on one side of more than a foot of the bark, was bored by above a dozen caterpillars of the clear underwing (*Ægeria asiliformis*, STEPHENS), without seeming to have its growth at all retarded.†

It does not appear that a minute moth, called by Leeuwenhoeck, who writes its history, the wolf, and by Haworth the mottled-woollen (*Ph. Tinea granella*, LINNÆUS), is so abundant in Britain as to do much damage to the grain stored in granaries, upon which it feeds. But it seems to have created considerable alarm on the Continent. It has been found near London, and *may* increase with us. The caterpillar, which is smooth and white, ties together with silk several grains of wheat, barley, rye, or oats, weaving a gallery between them, from which it projects its head while feeding; the grains, as Réaumur remarks, being prevented from rolling or slipping by the silk which unites them. He justly ridicules the absurd notion of its filing off the outer skin of

* Kirby and Spence, vol. i. p. 197.
† See vol. i. p. 181.

the wheat by rubbing upon it with its body, the latter being the softer of the two; and he disproved, by experiment, Leeuwenhoeck's assertion that it will also feed on woollen cloth. It is from the end of May till the beginning of July that the moths, which are of a silvery grey, spotted with brown, appear and lay their eggs in granaries.

The caterpillar of another still more singular grain moth (*Tinea Hordei*, KIRBY and SPENCE) proves sometimes very destructive to granaries. The mother moth, in May or June, lays about twenty or more eggs on a grain of barley or wheat; and when the caterpillars are hatched they disperse, each selecting a single grain. M. Réaumur imagines that sanguinary wars must sometimes arise, in cases of preoccupancy, a single grain of barley being a rich heritage for one of these tiny insects; but he confesses he never saw such contests. When the caterpillar has eaten its way into the interior of the grain, it feeds on the farina, taking care not to gnaw the skin nor even to throw out its excrements, so that except the little hole, scarcely discernible, the grain appears quite



Transformations of the grain moths. *a*, grain of barley, including a caterpillar; *b*, *c*, the grain cut across, seen to be hollowed out, and divided by a partition of silk; *d*, the moth (*Tinea Hordei*); *e*, grains of wheat tied together by the caterpillar, *f*; *g*, the moth (*Euplocamus granella*).

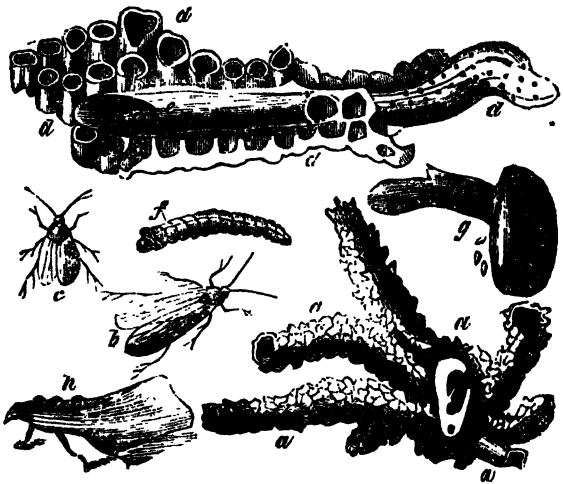
sound. When it has eaten all the farina, it spins itself a case of silk within the now hollow grain, and changes to a pupa in November.*

Two other caterpillars of a different family, the honeycomb moth (*Galleria cercana*, FABR.), and the honey moth (*G. alvearia*, FABR.), the first having square, and the second rounded wings,† do very considerable damage to the hives of bees. The moths of both, according to Réaumur, appear about the end of June or beginning of July; and when in danger they run rather than fly, gliding with such celerity that they can easily elude the vigilance of the bees, which, indeed, if we may trust Swammerdam, never attack them, nor prevent their entrance into the hives, unless they chance to brush against them in their passage. But Réaumur actually saw the bees pursue one, though without success. It becomes easy for a moth, at all events, to lay eggs among the combs; or, as Keys says, at the entrance of the hive: this writer adds, "she spins a close and strong web to defend the young;" ‡ which is impossible, as no insect, subsequent to its larva state, can spin.

The caterpillar of the first species, "wherever it passes," says Swammerdam, "gnaws round holes through the waxen cells, one caterpillar sometimes breaking open and destroying fifty or sixty cells. Wherever it penetrates it always fabricates a hollow tubulated web, in which, as a rabbit in its burrow, it can very swiftly pass from one part to another, and speedily run back again. It fills the whole comb with such webs, and turns itself in them every way into various bendings and windings; so that the bees are not only perplexed and disturbed in their work, but they frequently entangle themselves by the claws and hairs of their legs in those webs, and the whole hive is destroyed."

The other species he accuses of being not only destructive to the wax, but to the bees themselves. "I

* Réaumur, Mém., vol. ii. p. 486, &c.
† Stephens's Catalogue, vol. ii. p. 213.
‡ Keys, Treatise on Bees, p. 178, edit. 1814.



Transformations of the honeycomb moths. *a a a*, Galleries of the cell-boring caterpillar; *b*, the female; c, the male moth (*Galleria alvearia*); *d d d d*, galleries of the wax eating caterpillar, *e*, seen at the entrance; *f*, the same exposed; *g*, its cocoon; *h*, the moth (*Galleria cereana*).

saw one of these little caterpillars," he says, "whilst it was still small, and was breaking the cells in which the pupa of the bees lie, and eating the wax there, cover up these pupæ with its excrements, so that they could scarcely be known." He adds with great naïveté, "I have learned these matters much against my inclination, and have been full of wrath against the insect for thus defiling and killing some bee pupæ which I had designed to observe in their changes."*

M. Bazin, a friend of Réaumur's, discovered the caterpillar of a moth of this order feeding on chocolate, of which it seemed very choice, always preferring that

* Swammerdam, vol. i. p. 225.

which had the finest flavour. The moth is sometimes produced in September, and sometimes in the beginning of the following summer. It is probable that, like the cheese-fly, it might, in default of chocolate, select some other aliment.*

GRUBS.

WE frequently hear farmers and gardeners complaining that their produce is destroyed by "*the* grub;" they might with equal propriety accuse "*the* bird" when their ripe seeds are devoured by sparrows, chaffinches, linnets, and other seed-eaters. Instead of one sort of grub, as the expression seems to indicate, we are far under the mark in reckoning a thousand species indigenous to Britain, each peculiar in its food and its manners. We shall, however, adhere as nearly as possible to the terms in common use; but as the larvæ of the crane-flies (*Tipulidæ*, LEACH), being without legs, cannot be accurately ranked with the legged grubs of beetles, we shall consider them as maggots, though they are usually termed grubs by the farmers.

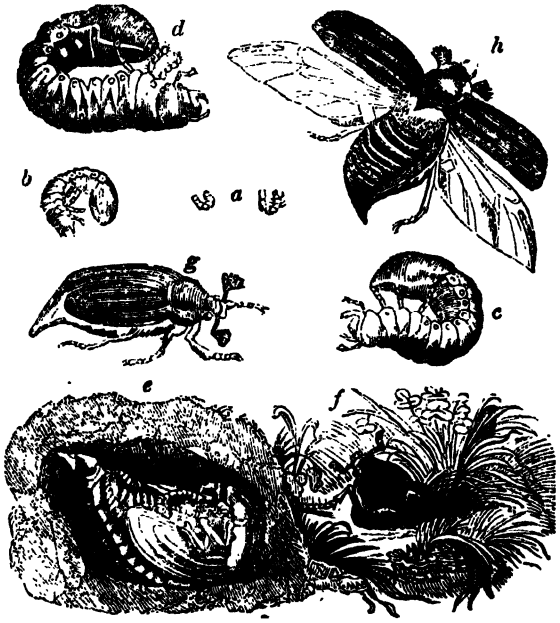
The most destructive, perhaps, of the creatures usually called grubs, are the larvæ of the may-bug or cockchafer (*Melolontha vulgaris*), but too well known, particularly in the southern and midland districts of England, as well as in Ireland, where the grub is called the Connaught worm;† but fortunately not abundant in the north. We only once met with the cockchafer in Scotland, at Sorn, in Ayrshire. (J. R.) Even in the perfect state, this insect is not a little destructive to the leaves of both forest and fruit trees. In 1823, we remember to have observed almost all the trees about Dulwich and Camberwell defoliated by them; and Salisbury says, the leaves of the oaks in Richmond Park were so eaten by them, that scarcely an entire leaf was left. But it is in their previous larva state that they are most destructive, as we shall see by tracing their history.

* Réaumur, vol. iii. p. 277.
† Bingley, Anim. Biog. vol. iii. p. 230.

The mother cockchafer, when about to lay her eggs, digs into the earth of a meadow or corn-field to the depth of a span, and deposits them in a cluster at the bottom of the excavation. Rösel, in order to watch their proceedings, put some females into glasses half-filled with earth, covered with a tuft of grass and a piece of thin muslin. In a fortnight, he found some hundreds of eggs deposited, of an oval shape and a pale yellow colour. Placing the glass in a cellar, the eggs were hatched towards autumn, and the grubs increased remarkably in size. In the following May they fed so voraciously that they required a fresh turf every second day; and even this proving too scanty provender, he sowed in several garden pots a crop of peas, lentils, and salad, and when the plants came up he put a pair of grubs in each pot; and in this manner he fed them through the second and third years. During this period, they cast their skins three or four times, going for this purpose deeper into the earth, and burrowing out a hole where they might effect their change undisturbed; and they do the same in winter, during which they become torpid and do not eat.

When the grub changes into a pupa, in the third autumn after it is hatched, it digs a similar burrow about a yard deep; and when kept in a pot, and prevented from going deep enough, it shows great uneasiness and often dies. The perfect beetle comes forth from the pupa in January or February; but it is then as soft as it was whilst still a grub, and does not acquire its hardness and colour for ten or twelve days, nor does it venture above ground before May, on the fourth year from the time of its hatching. At this time, the beetles may be observed issuing from their holes in the evening, and dashing themselves about in the air as if blind.

During the three summers then of their existence in the grub state, these insects do immense injury, burrowing between the turf and the soil, and devouring the roots of grass and other plants; so that the turf may easily be rolled off, as if cut by a turfing spade, while the soil underneath for an inch or more is turned into soft mould



Transformations of the cockchafer (*Melolontha vulgaris*). *a*, Newly hatched larvæ. *b*, larva, one year old. *c*, the same larva at the second year of its growth. *d*, the same three years old. *e*, section of a bank of earth, containing the chrysalis of the fourth year. *f*, the chafer first emerging from the earth. *g*, the perfect chafer in a sitting posture. *h*, the same flying.

like the bed of a garden. Mr. Anderson, of Norwich, mentions having seen a whole field of fine flourishing grass so undermined by these grubs, that in a few weeks it became as dry, brittle, and withered as hay.* Bingley also tells us that "about sixty years ago, a farm near

* Philosoph. Trans. xliv. 579.

Norwich was so infested with cockchafers, that the farmer and his servants affirmed they gathered eighty bushels of them; and the grubs had done so much injury, that the court of the city, in compassion to the poor fellow's misfortune, allowed him twenty-five pounds."* In the year 1785, a farmer, near Blois, in France, employed a number of children and poor persons to destroy the cockchafers at the rate of two liards a hundred, and in a few days they collected fourteen thousand.†

"I remember," says Salisbury, "seeing, in a nursery near Bagshot, several acres of young forest trees, particularly larch, the roots of which were completely destroyed by it, so much so that not a single tree was left alive."‡ We are doubtful, however, whether this was the grub of the cockchafer, and think it more likely to have been that of the green rose-beetle (*Cetonia aurata*), which feeds on the roots of trees.

The grub of an allied genus, the midsummer chafer (*Zantheumia solstitialis*, LEACH), has for the last two years been abundant on Lewisham Hill, Blackheath, doing considerable injury to herbage and garden plants. This beetle may be known from being smaller and paler than the cockchafer, and from its not appearing before midsummer. The grub is very similar.

The best way of preventing the ravages of these insects would be to employ children to collect the perfect insects when they first appear, before they lay their eggs; but when a field is once overrun with the larva, nothing can be done with it, except paring and burning the surface, or ploughing it up, and turning in a flock of ducks or other poultry, or a drove of pigs, which are said to eat these grubs, and to fatten on the fare. Drenching the field with stable urine§ by means of reservoir-carts, like those used for watering roads, would, if sufficiently done, both kill the grubs and beneficially manure the land.

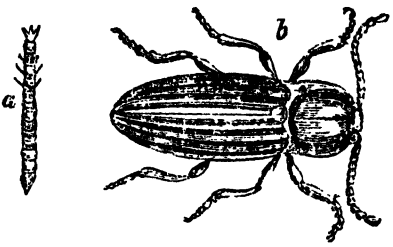
* Anim. Biog. iii. 233.
† Anderson's Recr. in Agricult. iii. 420. ‡ Hints, 71.
§ See the Harleian Dairy System, p. 222.

The grub called the *wire-worm*, though not very appropriately, is the larva of one of the spring or click beetles (*Hemirhipus lineatus*, and *H. obscurus*, LATREILLE), known by their long flattish body, and their power of springing with a clicking sound out of the hand when caught. In some works on agriculture, the larva of a common crane-fly (*Tipula oleracea* or *T. crocata*) is called the *wire-worm*,—we suppose by mistake.* The grubs of the click-beetles, just alluded to, are said by Bierscander† and by Mr. Paul of Starston, Norfolk,‡ who watched their transformations, to continue five years before producing the perfect insect. During this time the grub feeds chiefly on the roots of wheat, rye, oats, barley, and grass; but seems also sometimes to attack the larger roots of potatoes, carrots, and salads. Its ravages are often so extensive as to cut off entire crops of grain. It appears to be most partial to land newly broken up; and has not been found so abundant in meadows and pastures, unless in fields recently laid down with grass. "The wire-worm," says Spence, "is particularly destructive for a few years in gardens recently converted from pasture ground. In the botanic garden at Hull, thus circumstanced, a great proportion of the annuals sown in 1813 were destroyed by it. A very simple and effectual remedy, in such cases, was mentioned to me by Sir Joseph Banks. He recommended that slices of potatoes, stuck upon skewers, should be buried near the seeds sown, examined every day, and the wire-worms, which collect upon them in great numbers, destroyed." §

The wire-worm is long, slender, and very tough and hard; but otherwise it has no resemblance to wire, being whitish in colour, of a flattish form, and jointed or ringed. Its breathing spiracles, two in number, are on the back of its last ring.

An insect of this family (*Elater noctilucus*, LINN.) is exceedingly destructive, in the West Indies, to the sugar-

* See Loudon's Encycl. of Agricult. § 6921.
† Act. Holm. 1779, p. 284. ‡ Kirby and Spence, i. 182.
§ Intr. i. 182-3.



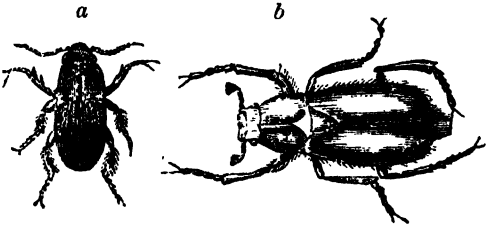
a, Wire worm ; *b*, Click beetle.

cane; the grub, according to Humboldt and Bonpland, feeding on its roots and killing the plants." *

Instances are by no means rare, however, of insects being accused of depredations of which they are not guilty, from the mere circumstance of their being found in abundance where ravages have been committed by others that have naturally disappeared. It is not improbable that this was the case with a grub of some beetle *(Staphylinidæ?)* mentioned by Mr. Walford, and mistaken by him for the wire-worm. Out of fifty acres of wheat sown in 1802, ten had been destroyed in October by this grub eating into the centre of the young stem an inch below the surface and killing the plant.† It seems still more probable that the grub of a native beetle *(Zabrus gibbus*, Stephens), which has been found in considerable numbers near Worthing, Brighton, Hastings, and Cambridge, has been unjustly blamed as a destroyer of corn; though we have the respectable authority of Germar, who, with other members of the society of Natural History of Halle, imagined he had ascertained the fact. In the spring of 1813, about two hundred and thirty acres of young wheat are said to have been destroyed by it; and it is farther supposed to be

* Géog. des Plantes, 136.
† Linn. Trans. ix. 156-61.

the same insect which caused great destruction in Italy in 1776. This grub is said to take probably three years in coming to a beetle, in which state it is alleged to clamber up the stems at night to get at the corn. It is important to remark, that along with these grubs were found those of a chafer (*Melolontha ruficornis*, FABR.), in the proportion of about a fourth.*



a, Zabrus gibbus; *b*, Melolontha ruficornis.

To this account Mr. Stephens appends the shrewd questions—"May not these herbivorous larvæ [of the chafer] have been the principal cause of mischief to the wheat, while those of the *Zabrus* rather contributed to lessen their numbers than to destroy the corn? And is it not probable that the perfect insects ascend the corn for the purpose of devouring the insect parasites thereon? This is a subject," he justly adds, "that requires investigation, as it is highly important, for the interests of the agriculturists in those districts where the insect abounds, that the question should be thoroughly set at rest; because, should the Zabri depart from the habits of the group to which they belong, and become herbivorous instead of carnivorous, their destruction would be desirable; while, on the contrary, if they destroy the devourers of our produce their preservation should be attempted." †

* Germar, Mag. der Entomol., i. 1-10; and Kirby and Spence, i. 169.

† Stephens, Illustrations, i. Mandib. pp. 4 and 110.

We have little doubt that Mr. Stephens is right, and Germar wrong; but it would be improper to decide the question by analogy unsupported by direct experiment. One thing is certain, that both this family (*Harpalidæ*, MacLeay) and the whole section (*Adephaga*, Clairville) are not herbivorous, but carnivorous.* Similar errors will come under our notice, as we proceed, not more defensible than that of the old soldier causing caterpillars in France.

Even when agricultural produce escapes being devoured at the root, or the young shoots eaten up, the seeds are often made the prey of the grubs of beetles and weevils. Among the first, the gnawing beetles (*Bruchidæ*. Leach) are very destructive. In North America, the pea-beetle (*Bruchus Pisi*, Linn.) commits such extensive depredations on pulse, that in some districts the sowing of peas has been abandoned as useless. Kalm, the Swedish traveller, having witnessed these depredations in America, became quite alarmed when he discovered the insect among some peas he had brought to Sweden, lest he should be the means of introducing so formidable a pest.† His fears seem to us to have been in a great measure groundless; for, probably, the insect may be indigenous to Sweden, as it is to Britain, though from circumstances of climate, and other causes, it is seldom produced in such numbers with us as to occasion extensive damage. It may have been the same or an allied species of grub mentioned by Amoroux as having spread an alarm in France in 1780, when the old fancy of its being poisonous induced the public authorities to prohibit peas from being sold in the markets.‡ The insect most destructive to our peas is the pulse-beetle (*Bruchus granarius*, Linn.), which sometimes lays an egg on every pea in a pod, which the grub, when hatched, destroys. In the same way, clover-seed is

* See an illustration in vol. i. p. 196.

† Kalm's Travels, vol. i. p. 173.

‡ Amoroux, Insectes Venimeux, 288. Kirby and Spence, i. 177.

often attacked by two or more species of small weevil (*Apion*, HERBST), known by the yellow colour of their thighs or their feet; and when the farmer expects to reap considerable profit, he finds nothing but empty husks.

We have mentioned the ravages committed in granaries by the caterpillars of small moths; but these are rivalled in the work of destruction by several species of grubs. One of these grubs is called by the French cadelle (*Trogosita mauritanica*, OLIVIER), and is reported to have done more damage to housed grain than any other insect.* The pest of the granaries, which is but too well known in this country, is the grain weevil (*Calandra granaria*, CLAIRVILLE), the same, probably, which is mentioned by Virgil,

> Populatque ingentem farris acervum
> Curculio. *Georg.* i. 87.
>
> ——— The high stacks of corn
> Are wasted by the weevil. *Trapp.*

Kirby and Spence calculate that a single pair of weevils may produce in one season 6000 descendants; and they were told by an extensive brewer that he had collected and destroyed them by bushels,†—meaning, no doubt, insects and damaged grain together.

Another beetle grub, popularly called the meal-worm, the larva of *Tenebrio molitor*, LINN., which lives in that

Corn weevil (*Calandra granaria*), magnified.

* Olivier, ii. 19. † Intr. i. 173.

state two years, does no little damage to flour, as well as to bread, cakes, biscuit, and similar articles. Accounts are also given of the ravages committed by the grubs of other beetles, of several species apparently not well ascertained, upon different sorts of provisions, such as bacon, ham, dried tongues, ship-biscuit, &c. Sparrman tells us that he has witnessed the ground peas on shipboard so infested with these grubs, that they were seen in every spoonful of the soup. In the case of soup, or of other food which has been exposed to heat, the only inconvenience is the disgust which must ensue; but, unfortunately, there may sometimes occur circumstances of a more serious nature,—from either the eggs or the insects themselves being incautiously swallowed alive. We do not wish, however, to create, so much as to allay, the fears entertained by those who are unacquainted with the habits of insects; and nothing we are persuaded will do this more effectually than a statement of facts well ascertained. "Several people," says the Abbé de la Pluche, "never eat fruit because they believe that spiders and other insects scatter their eggs upon it at random;"* but even if this were so, as it is not, it would be impossible for the young, should they be hatched in the stomach, to live there for an instant. The possible cases in which this may occur we shall now briefly notice; they are fortunately very rare.

The grub of the nut weevil (*Balaninus Nucum*, GERMAR) might, perhaps, by rare accident, get into the stomach, either of man or of the quadrupeds which feed on nuts; but as it is by no means so tenacious of life as the grub of the churchyard-beetle (*Blaps mortisaga*) it is unlikely that it would produce any considerable disorder. The weevil in question, like the rest of its congeners, is furnished with an instrument for depositing its eggs considerably different from those of the ichneumons and saw-flies. For this purpose the weevil makes use of its long horny beak (*Rostrum*) to

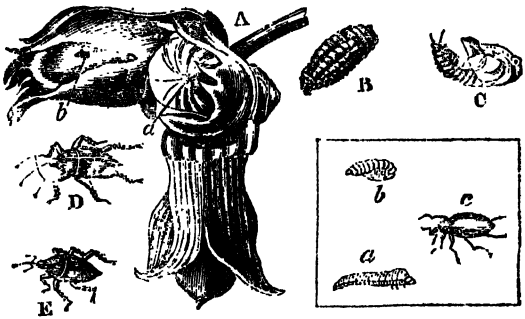
* Spectacle de la Nature, i. 65.

drill a hole in filberts and hazel-nuts, while in their young and soft state, about the beginning of August. The mother weevil may then be seen eagerly running over the bushes, and it would appear that she always rejects the nuts in which one of her neighbours may have previously laid an egg; at least we never find two grubs in the same nut. The egg which is thus thrust into the young nut, is of a brown colour, and is hatched in about a fortnight, the grub feeding on the interior of the shell as well as the soft pulp, till the one becomes too hard and the other too dry to be nutritive. It is remarkable that, during this period, he takes care not to injure the kernel, but permits it to ripen before he attacks it. Had he done this prematurely, he would have ultimately been starved, as he has not the power of perforating another nut when the first is consumed. It is said also that he is very careful to preserve the original hole made by the mother, by gnawing around its inner edges, in order to facilitate his exit,* which he effects when the nut falls to the ground in September or October. The hole found in the nut appears much too small to have admitted of its passage; but from being very soft it no doubt stretches itself out for the purpose, using its short claws as instruments of motion.

Rösel, in order to observe the transformation of these nut grubs, put a number of them, at the commencement of winter, into glasses half filled with earth, covered with green turf. All of them dug directly down into the earth, remained there all the winter, and did not change into pupæ till the following June; the perfect weevils appeared from the 1st till about the 20th of August, but still kept under ground for the first week after their change.

"During the autumn," says Salisbury, "we frequently observe a small red weevil busily employed in traversing the branches of apple-trees, on which it lays its eggs by perforating the bloom buds. In the spring these hatch, and the grubs feed on the petals of the

* Bingley, Animal Biography, vol. iii., p. 251.



Nut and apple-tree beetles. A, a branch of the filbert-tree. *a*, egg hole in the nut; *b*, exit hole of the grub B, the larva of the nut beetle. C, the same in the pupa state. D, female beetle. E, male beetle. *c*, the beetle that destroys the bloom-bud of the apple-tree; *a*, the same in the larva state; *b*, the chrysalis of the same.

flowers, drawing up the whole flower into a cluster by means of their web. The bloom thus becomes destroyed, and the grub falls to the ground, where it lays itself up in the chrysalide state; and in the autumn afterwards we find the weevil renewed, which again perforates the buds, and causes a similar destruction in the following spring. Mr. Knight, in his treatise on the apple, mentions a beetle which commits great destruction on the apple-trees in Herefordshire; but I do not think it the same as the one I have described above, and which is very common in the gardens near London."* Salisbury's weevil is probably the *Anthonomus Pomorum* of Germar; and Knight's, his *Polydrusus Mali*. Another weevil (*Rhynchites Bacchus*, Herbst), one of our most splendid but not very common native insects, bores into the stone of the cherry, &c., while it is young and soft, and deposits an egg there, as the nut weevil does in the nut.

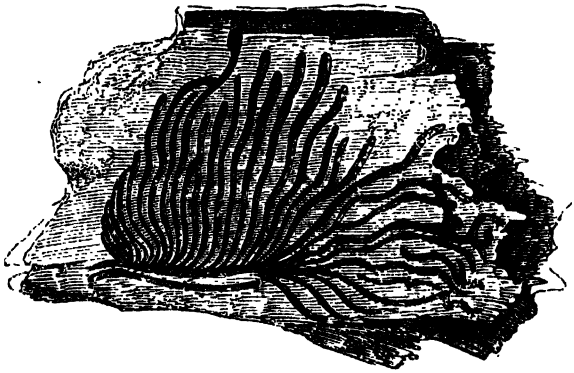
* Salisbury's Hints on Orchards, p. 92.

Perhaps the most voracious grub on record is that of a large and beautiful beetle (*Calosoma sycophanta*, Weber), which is rare in Britain. It is sometimes found in the nests of the processionary and other gregarious caterpillars, so gorged with those it has devoured that it can scarcely move without bursting. Not contented with this prey alone, however, the younger grubs are said "often to take advantage of the helpless inactivity into which the gluttony of their maturer comrades has thrown them, and from mere wantonness, it should seem, when in no need of other food, pierce and devour them."* It is a familiar occurrence to those who breed insects to find caterpillars, whose natural food is leaves, devouring others in the same nurse-box; and without any apparent discrimination whether these are the progeny of their own mother, or of a different species.† (J.R.)

We have frequently observed a very remarkable instinct in the grubs of a species of beetle (*Scolytus destructor*, Geoffroy), which lives under the dead bark of trees. The mother insect, as is usual with beetles, deposits her eggs in a patch or cluster in a chink or hole in the bark; and when the brood is hatched, they begin feeding on the bark which had formed their cradle. There is, of course, nothing wonderful in their eating the food selected by their mother; but it appears that, like the caterpillars of the clothes moth, and the tent insects, they cannot feed except under cover. They dig, therefore, long tubular galleries between the bark and the wood; and, in order not to interfere with the *runs* of their brethren, they branch off from the place of hatching like rays from the centre of a circle: though these are not always in a right line, yet, however near they may approach to the contiguous ones, none of them ever break into each other's premises. We cannot but admire the remarkable instinct implanted in these grubs by their Creator; which guides them thus in lines diverging farther and farther as they increase in size, so

* Kirby and Spence, vol. i. p. 277.

† See also De Geer, i. 533, &c., and Réaumur, ii. 413.



Bark mined in rays by beetle-grubs.

that they are prevented from interfering with the comforts of one another.

The various instances of voracity which we have thus described sink into insignificance when compared with the terrible devastation produced by the larvæ of the locust (*Locusta migratoria*, LEACH),—the scourge of Oriental countries. "A fire devoureth before them," says the Prophet Joel, "and behind them a flame burneth: the land is as the garden of Eden before them, and behind them a desolate wilderness; yea, and nothing shall escape them. The sound of their wings is as the sound of chariots, of many horses running to battle; on the tops of mountains shall they leap, like the noise of a flame of fire that devoureth the stubble, as a strong people set in battle array. Before their faces, the people shall be much pained, all faces shall gather blackness. They shall run like mighty men; they shall climb the wall like men of war; and they shall march every one in his ways, and they shall not break their ranks; neither shall one thrust another."*

* Joel ii. 2, &c.

The intelligent traveller, Dr. Shaw, was an eye-witness of their devastations in Barbary in 1724, where they first appeared about the end of March, their numbers increasing so much in the beginning of April as literally to darken the sun; but by the middle of May they began to disappear, retiring into the Mettijiah and other adjacent plains to deposit their eggs. "These were no sooner hatched in June," he continues, "than each of the broods collected itself into a compact body, of a furlong or more in square; and marching afterwards directly forwards toward the sea, they let nothing escape them,—they kept their ranks like men of war; climbing over, as they advanced, every tree or wall that was in their way; nay, they entered into our very houses and bed-chambers, like so many thieves. The inhabitants, to stop their progress, formed trenches all over their fields and gardens, which they filled with water. Some placed large quantities of heath, stubble, and other combustible matter, in rows, and set them on fire on the approach of the locusts; but this was all to no purpose, for the trenches were quickly filled up, and the fires put out, by immense swarms that succeeded each other.

"A day or two after one of these hordes was in motion, others were already hatched to march and glean after them. Having lived near a month in this manner, they arrived at their full growth, and threw off their nympha state by casting their outward skin. To prepare themselves for this change, they clung by their hinder feet to some bush, twig, or corner of a stone; and immediately, by using an undulating motion, their heads would first break out, and then the rest of their bodies. The whole transformation was performed in seven or eight minutes; after which they lay for a small time in a torpid, and, seemingly, in a languishing condition; but as soon as the sun and the air had hardened their wings by drying up the moisture that remained upon them after casting their sloughs, they resumed their former voracity, with an addition of strength and agility. Yet they continued not long in this state before they were entirely dispersed." *

* Shaw's Travels, p. 257.

It is difficult to form an adequate conception of the swarms of locusts which, in 1797, invaded the interior of southern Africa, as recorded by Mr. Barrow. In the part of the country where he was, the whole surface of the ground, for an area of nearly two thousand square miles, might literally be said to be covered with them. The water of a very wide river was scarcely visible, on account of the dead carcases of locusts that floated on the surface, drowned in the attempt to come at the reeds that grew in it. They had devoured every blade of grass, and every green herb, except the reeds. But they are not precisely without a choice in their food. When they attack a field of corn just come into ear, they first, according to Mr. Barrow, mount to the summit and pick out every grain before they touch the leaves and stem, keeping the while constantly in motion, with the same intent of destruction always in view. When the larvæ, which are much more voracious than the perfect insects, are on a march during the day, it is utterly impossible to turn the direction of the troop, and this seems usually to correspond with that of the wind. Towards the setting of the sun the march is discontinued, when the troop divides into companies that surround the small shrubs, or tufts of grass, or ant-hills, in such thick patches, that they appear like so many swarms of bees; and in this manner they rest till day-light. At these times it is that the farmers have any chance of destroying them; this they sometimes effect by driving among them a flock of two or three thousand sheep, by whose restlessness great numbers of them are trampled to death. The year 1797 was the third of their continuance in Sneuwberg; and their increase had been more than a million-fold from year to year.

This district, however, had been entirely free from them for ten years preceding their visit in 1794. Their former exit was singular: all the full-grown insects were driven into the sea by a tempestuous north-west wind, and were afterwards cast up on the beach, where they formed a bank of three or four feet high, and extending to a distance of nearly fifty miles. When this mass became putrid, and the wind was at south-east, the stench

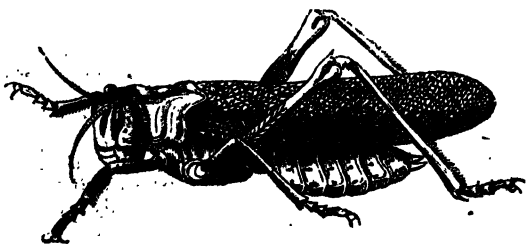
was sensibly felt in several parts of Sneuwberg, although distant at least a hundred and fifty miles.*

Pallas gives a more detailed account of the daily proceedings of the larvæ of the Italian locust (*Locusta Italica*, LEACH). "In serene weather," he tells us, "the locusts are in full motion in the morning, immediately after the evaporation of the dew; and if no dew has fallen, they appear as soon as the sun imparts his genial warmth. At first, some are seen running about like messengers among the reposing swarms, which are lying partly compressed upon the ground at the side of small eminences, and partly attached to tall plants and shrubs. Shortly after the whole body begins to move forward in one direction, and with little deviation. They resemble a swarm of ants, all taking the same course, at small distances, but without touching each other: they uniformly travel towards a certain region as fast as a fly can run, and without leaping, unless pursued; in which case, indeed, they disperse, but soon collect again and follow their former route. In this manner they advance from morning to evening without halting, frequently at the rate of a hundred fathoms and upwards in the course of a day. Although they prefer marching along high roads, foot-paths, or open tracts, yet, when their progress is opposed by bushes, hedges, and ditches, they penetrate through them: their way can only be impeded by the waters of brooks or canals, as they are apparently terrified at every kind of moisture. Often, however, they endeavour to gain the opposite bank, with the aid of overhanging boughs; and, if the stalks of plants or shrubs be laid across the water, they pass in close columns over these temporary bridges, on which they even seem to rest, and enjoy the refreshing coolness. Towards sun-set, the whole swarm gradually collect in parties, and creep up the plants, or encamp on slight eminences. On cold, cloudy, or rainy days, they do not travel. As soon as they acquire wings, they progressively disperse, but still fly about in large swarms."†

* Barrow's Travels in South Africa, p. 257.
† Travels in Russia, ii. 422-6.

When Captains Irby and Mangles were travelling round the southern extremity of the Dead Sea, in the end of May, they had an opportunity of observing these insect depredators. "In the morning," say they, "we quitted Shobek. On our way we passed a swarm of locusts that were resting themselves in a gully; they were in sufficient numbers to alter apparently the colour of the rock on which they had alighted, and to make a sort of crackling noise while eating, which we heard before we reached them. Volney compares it to the foraging of an army. Our conductors told us they were on their way to Gaza, and that they pass almost annually."*

Even our own island has been alarmed by the appearance of locusts, a considerable number having visited us in 1748; but they happily perished without propagating. Other parts of Europe have not been so fortunate. In 1650 a cloud of locusts were seen to enter Russia in three different places; and they afterwards spread themselves over Poland and Lithuania in such astonishing multitudes, that the air was darkened, and the earth covered with their numbers. In some places they were seen lying dead, heaped upon each other to the depth of four feet; in others they covered the surface of the ground like a black cloth: the trees bent with their weight, and the



Locust.

* Irby and Mangles' Travels in Egypt and Syria, p. 113.

damage the country sustained exceeded computation.* They have frequently come also from Africa into Italy and Spain. In the year 591 an infinite army of locusts, of a size unusually large, ravaged a considerable part of Italy, and being at last cast into the sea (as seems for the most part to be their fate), a pestilence, it is alleged, arose from their stench, which carried off nearly a million of men and beasts. In the Venetian territory, likewise, in 1478, more than 30,000 persons are said to have perished in a famine chiefly occasioned by the depredations of locusts.†

MAGGOTS.

Adhering to the distinction of terming those larvæ which are destitute of feet, *maggots*, we shall notice here a very destructive one, which is sometimes popularly called *the* grub, and sometimes confounded with the wire-worm.‡ We allude to the larvæ of one or two common species of crane-flies (*Tipulidæ*), well known by the provincial names of father-long-legs, Jenny-spinners, and tailors. These insects are so common in some meadows, that, being very shy and fearful of danger, they rise in swarms at every step — some of them flying high, others only skipping over the grass, and others running and using their long legs as the inhabitants of marshy countries use stilts, and employing their wings like the ostrich to aid their limbs.

These flies deposit their eggs in the earth; sometimes in grass-fields or moist meadows, and sometimes in the tilled ground of gardens and farms. For this purpose the female is provided with an ovipositor well adapted to the operation, consisting of a sort of pincers or forceps of a horny consistence, and sharp at the point. By pressure, as Réaumur says, the eggs may be extruded from this in the same way as the stone can be easily squeezed out of a ripe cherry, as in the following figure.

* Bingley, Anim. Biog. iii. 280.

† Mouffet, Theatr. Insect. 128.

‡ See Stickney's Observ. on the Grub, 8vo. Hull, 1800.

Ovipositor and eggs of the crane-fly (*Tipula*).

The eggs are exceedingly small and black, like grains of gunpowder, and each female lays a good many hundreds. The position which she assumes appears somewhat awkward, for she raises herself perpendicularly on her two hind-legs, using her ovipositor as a point of support, and resting with her fore-legs upon the contiguous herbage. She then thrusts her ovipositor into the ground as far as the first ring of her body, and leaves one or more eggs in the hole; and next moves onwards to another place, but without bringing herself into a horizontal position. The maggot, when hatched from the egg, immediately attacks the roots of the grass and other herbage which it finds nearest to it; and of course the portion of the plant above ground withers for lack of nourishment.

The maggots of this family which seem to do most injury are those of *Tipula oleracea* and *T. cornicina*. In the summer of 1828, we observed more than an acre of ground, adjoining the Bishop of Oxford's garden at Blackheath, as entirely stripped, both of grass and everything green, as if the turf had been pared off from the surface, the only plant untouched being the tiny bird-tare

(*Ornithopus perpusillus*). On digging here to learn the cause, we found these larvæ already full-fed, and about to pass into pupæ, after having left nothing upon which they could subsist. It was not a little remarkable that they seemed to be altogether confined to this spot; for we did not meet with a single foot of turf destroyed by them in any other part of the heath, or in the adjacent fields. So very complete, however, was their destruction of the roots on the spot in question, that even now, at the distance of two years, it is still visibly thinner of herbage than the parts around it. (J. R.)

Réaumur gives a similar account of their ravages in Poitou, where, in certain seasons, the grass of the low moist meadows has been so parched up in consequence as not to afford sufficient provender for the cattle. He describes the soil in Poitou as a black peat mould; and was the same in which we found them at Blackheath with this difference, that the spot was elevated and dry. According to M. Réaumur, also, their only food is this sort of black mould, and not the roots of grass and herbage, which he thinks are only loosened by the burrowing.* This view of the matter appears strongly corroborated by the fact that several species of the family feed upon the mould in the holes of decaying trees, particularly the larva of a very beautiful one (*Ctenophora flaveolata*, MEIGEN), which is very rare in Britain. It is proper to mention, however, that Mr. Stickney's experiments,† contrary to the conclusions of Réaumur, indicate that these larvæ devour the roots of grass; and Stewart says they "feed on the roots of plants, corn and grasses, and are thence destructive to gardens, fields and meadows. They prevailed in the neighbourhood Edinburgh, and other places in Scotland, in the of 1800, when they laid waste whole fields of oat other grain."‡

In many districts of England these insects eat off a large proportion of the wheat crop, particularly [illegible]

* Réaumur, v. 12, &c. ‡ Obs. on the Grub.
† Elements, ii. 267.

appear, when it had been sown on clover leys. "In the rich district," say Kirby and Spence, "of Sunk Island, in Holderness, in the spring of 1813, hundreds of acres of pasture have been entirely destroyed by them, being rendered as completely brown as if they had suffered a three months' drought, and destitute of all vegetation except a few thistles. A square foot of the dead turf being dug up, 210 grubs were counted on it; and, what furnishes a striking proof of the prolific powers of those insects, last year it was difficult to find a single one."*

It is worthy of remark that the mandibles of these destructive creatures, which are claw-shaped and transverse, do not act against each other as is usual among insects, but against two other pieces which are immoveable, convex, and toothed,—as if the under-jaw in quadrupeds were divided into two, and should act vertically on the two portions of the immoveable upper-jaw thrown in between them.

The maggot of a minute fly of the same family, known by the name of the wheat-fly (*Cecidomyia Tritici*, KIRBY and SPENCE), is frequently productive of great damage in the crops of wheat. Its history was first investigated by Marsham, and subsequently by Kirby and Spence, and several other intelligent naturalists. The parent fly is very small, not unlike a midge (*Culicoides punctata*, LATR.), of an orange colour, and wings rounded at the tip, and fringed with hairs.† The female is furnished with a retractile ovipositor, four times as long as the body, and as fine as a hair, for depositing her eggs, which she does in the glumes of the florets of the grain. The following account of its proceedings is given by Mr. Shireff, an intelligent farmer of East Lothian.

"Wheat-flies," he says, "were first observed here this season on the evening of the 21st of June, and, from the vast number seen, it is probable a few of them may have been in existence some days previous. The

* Intr. i. 318, note.

† Linn. Trans., iii. 243—iv. 234-240; v. 96.

eggs were visible on the 23rd, the larvæ on the 30th of that month, and the pupæ on the 29th of July. The flies were observed depositing eggs on the 28th, and finally disappeared on the 30th July; thus having existed throughout a period of thirty-nine days.

"The flies were observed to frequent the wheat-plant, including the thick-rooted couch-grass (*Triticum repens*). They generally reposed on the lower parts of the stems during the day, and became active about sunset, except when the wind was high. I have, however, seen them flying about on cloudy mornings, till seven o'clock; and, upon one occasion, witnessed them depositing their eggs, in a shaded situation, at two in the afternoon. Their movements appear to be influenced by the rays of light, of which they seem impatient, being active when the sun is below or near the horizon: they frequent the most umbrageous part of the crop, and shun that which is deficient in foliage.

"The flies almost invariably preferred the ears emerging from the vagina to those farther advanced, for depositing their eggs on; and as one side only of the ear is exposed when the plant is in this stage of growth, the other side generally remained uninjured. The fly deserted the fields as the crop advanced towards maturity, and were found longest on the spring-sown portion of the crop. It seemed to feed on the gum adhering to the newly emerged ears; and as there is a great diversity in the time of sowing wheat in this neighbourhood, and consequently of the ears escaping from the vagina, I attribute the unusual length of time it has existed this season, to the supply of food thus gradually furnished.

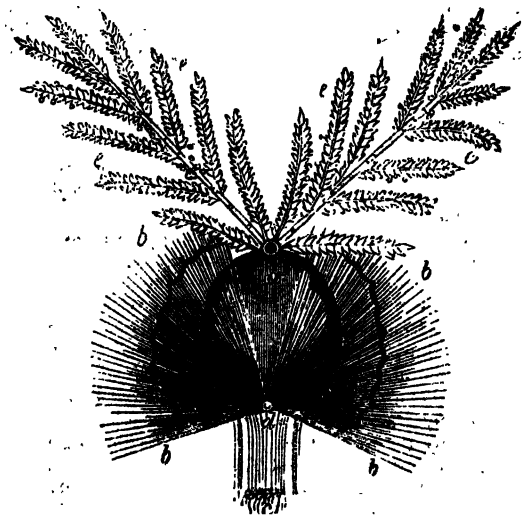
"The fly deposits its eggs with much intensity, and may easily be taken when so employed. Upon one occasion, I numbered thirty-five flies on a single ear; and, after carrying it a distance of a quarter of a mile, six of them still continued to deposit eggs. At another time, I placed a fly, then laying, between the face and glass of my watch, where it deposited several eggs, although invariably interrupted by the revolution of the moment hand.

"The eggs of the fly are generally found in clusters, varying in number from two to ten, upon the inner chaff, in which the furrowed side of the grain is embedded, and are also occasionally to be seen in the interior parts of the flower and chaff. The eggs are deposited by means of a long slender tube, and fixed with a glutinous substance possessed by the fly. A thread of glutinous matter frequently connects a cluster of eggs with the style, where the larvæ seem to subsist on the pollen; in one instance, fifteen eggs were numbered on such a thread, several of which were suspended on the portion extending between the chaff and the style. The fly not only seems thus to provide a conveyance from the larvæ to the style, but also food for their support. The anthers are prevented from leaving the style in consequence of being gummed down by the glutinous matter of the fly, and the pollen thereby detained for the use of the larvæ, which otherwise would, in part, be carried out of the glumes by the expansion of the filaments,—known to farmers by the term *bloom*. In the exertion of gumming down the anthers, many of the flies are entangled in the vascules of the corolla, and thus become a sacrifice to their maternal affection.

"The larvæ are produced from the eggs in the course of eight or ten days: they are at first perfectly transparent, and assume a yellow colour a few days afterwards. They travel not from one floret to another, and forty-seven have been numbered in one. Occasionally there are found in the same floret larvæ and a grain, which is generally shrivelled, as if deprived of nourishment; and although the pollen may furnish the larvæ with food in the first instance, they soon crowd around the lower part of the germen, and there, in all probability, subsist on the matter destined to have formed the grain."*

Another intelligent observer, Mr. Gorrie, of Annat Gardens, Perthshire, found that by the first of August all the maggots leave the ears, and go into the ground

* Loudon's Mag. of Nat. Hist., Nov. 1829, p. 450.



Germination of a grain of wheat. *a*, the heart of the grain, the part devoured by the insect. *b*, bag of the seed. *c*, the root. *d*, vessels to convey the nutriment for the root. *e*, feathers conveying the nutriment to fructify the seed.

about the depth of half an inch, where it is probable they pass the winter in the pupa state.*

It is interesting to learn that this destructive insect is providentially prevented from multiplying so numerously as it might otherwise do, by at least two species of ichneumons, which deposit their eggs in the larvæ. One of these (*Encyrtus insectorum*, Latr.) is very small, black, and shining. The other (*Platygaster Hiemalis*, Latr.) is also black, with red feet, and a blunt tail. These have been frequently mistaken for the wheat-fly; but as

* Loudon's Mag. of Nat. Hist., September, 1829, p. 324.

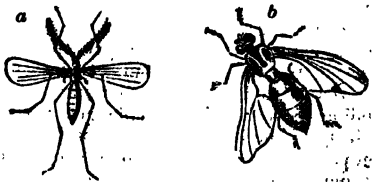
Transformations of the wheat-fly; *a*, the female fly magnified; *b*, larvæ, natural size, feeding; *c*, one magnified.

it has only *two* wings, while they have *four*, the distinction is obvious. In order to observe the proceedings of the ichneumons, Kirby placed a number of the larvæ of the wheat-fly on a sheet of white paper, and set a female ichneumon in the midst of them. She soon pounced upon her victim, and intensely vibrating her antennæ, and bending herself obliquely, plunged her ovipositor into the body of the larva, depositing in it a single egg. She then passed to a second, and proceeded in the same manner, depositing a single egg in each. Nay, when she examined one which she found had already been pricked, she always rejected it and passed to another.* Mr. Shireff repeated these experiments successfully, except that he saw an ichneumon twice prick the same maggot, which "writhed in seeming agony," and "it was again stung three times by the same fly." He adds, "the earwig also destroys the larvæ, three of which I successively presented to an earwig, which devoured them immediately."† Mr. Gorrie describes these ichneumons as appearing in myriads on the outside of the ear; but as impatient of bright light, sheltering themselves from the sun's rays among the husks.

Our English naturalists were for many years of opinion, that the insect called the Hessian-fly, so destructive to wheat crops in America, belonged to the same family (*Muscidæ*) with the common house-fly; and Mr. Mark-

* Linn. Trans. *ut supra.* † Loudon's Mag. *ut supra.*

wick, an intelligent naturalist, by a series of observations on a British fly (*Chlorops pumilionis*, Meigen) which attacks the stems of wheat, created no little alarm among agriculturists. Markwick's fly is less than a fourth of an inch in length, with dark shoulders striped with two yellow lines; and the maggot is white. He planted roots of wheat containing larvæ in a small flower-pot, and covered them with gauze. Each stem produced one of the above flies. The crop of wheat attacked by this maggot, though at first it appeared to fail, turned out well in consequence of numerous side shoots. It is only the early wheat sown in October that is affected by it.*



a, The Hessian-fly (*Cecidomyia destructor*); *b*, Markwick fly (*Chlorops pumilionis*), magnified.

It now appears that Markwick was altogether mistaken in identifying his insect with the Hessian-fly (*Cecidomyia destructor*, Say), which has been accurately described by Mr. Say in the 'Journal of the Academy of Natural Sciences of Philadelphia' for 1817. It is a little larger than our wheat-fly, more slender in the body, has longer legs, and is not orange, but black and yellow. The female deposits from one to eight or more eggs on a single plant of wheat, between the sheath of the lower leaf and the stem nearest the roots; in which situation, with its head towards the root or first joint, the young larva passes the winter, eating into the stem, but causing it to break.†

The devastation committed by the Hessian-fly seems to have been first observed in 1776, and it was erroneously supposed that the insect was conveyed among straw by the Hessian troops from Germany. It was first noticed in the wheat fields of Long Island, from which it spread gradually at the rate of fifteen or twenty miles round; and in 1789 it had advanced two hundred miles from its original station in Long Island. Other accounts state that it did not travel more than seven miles annually, and did little serious damage before 1788. Their numbers seem almost incredible. The houses in the infested districts swarmed with them to so great a degree, that every vessel was filled with them; five hundred were actually counted on a glass tumbler which had been set down for a few minutes with a little beer in it. They were observed crossing the Delaware river like a cloud; and even mountains do not seem to interrupt their progress.* We can well understand, therefore, that so formidable a ravager should have caused a very great alarm; and even our own government was in fear lest the insect should be imported. The privy council, indeed, sat day after day in deep consultation what measures should be adopted to ward off the danger of a calamity more to be dreaded, as they well knew, than the plague or the pestilence. Expresses were sent off in all directions to the officers of the customs at the different outports respecting the examination of cargoes,—despatches were written to the ambassadors in France, Austria, Prussia, and America, to gain information,—and so important altogether was the business deemed, that the minutes of council, and the documents collected from all quarters, fill upwards of two hundred pages.†

As in the case of the English wheat-fly, the American Hessian-fly has a formidable enemy in a minute four-winged fly (*Ceraphron destructor*, Say), which deposits its eggs in the larvæ. Were it not for the Ceraphron, indeed, Mr. Say is of opinion that the crops of wheat

* Kirby and Spence, vol. i. p. 172.
† Young, Annals of Agric., vol. xi.

would be totally annihilated in the districts where the Hessian-fly prevails.*

Those who have, from popular associations, been accustomed to look with disgust at the little white larvæ common in cheese, well known under the name of *hoppers*, will be somewhat surprised to hear the illustrious Swammerdam say, "I can take upon me to affirm that the limbs and other parts of this maggot are so uncommon and elegant, and contrived with so much art and design, that it is impossible not to acknowledge them to be the work of infinite power and wisdom, from which nothing is hid, and to which nothing is impossible."† But whoever will examine it with care, will find that Swammerdam has not exaggerated the facts.

The cheese-fly (*Piophila Casei*, FALLEN) is very small and black, with whitish wings, margined with black. It was one of those experimented upon by Redi to prove that insects, in the fabric of which so much art, order, contrivance, and wisdom appear, could not be the production of chance or rottenness, but the work of the same Omnipotent hand which created the heavens and the earth. This tiny little fly is accordingly furnished with an admirable instrument for depositing its eggs, in an ovipositor which it can thrust out and extend to a great length, so that it can penetrate to a considerable depth into the cracks of cheese, where it lays its eggs, 256 in number. "I have seen them myself," says Swammerdam, "thrust out their tails for this purpose to an amazing length, and by that method bury their eggs in the deepest cavities. I found in a few days afterwards a number of maggots which had sprung from those eggs, perfectly resembling those of the first brood that had produced the mother fly. I cannot but also take notice that the rottenness of cheese is really caused by these maggots; for they both crumble the substance of it into small particles and also moisten it with some sort of liquid, so that

* Journ. of Acad. Philadelph. *ut supra*.
† Bibl. Naturæ, vol. ii. p. 63.

the decayed part rapidly spreads. I once observed a cheese which I had purposely exposed to this kind of fly grow moist in a short time in those parts of it where eggs had been deposited, and had afterwards been hatched into maggots; though, before, the cheese was perfectly sound and entire." *

The cheese-hopper is furnished with two horny claw-shaped mandibles, which it uses both for digging into the cheese and for moving itself, being destitute of feet. Its powers of leaping have been observed by every one; and Swammerdam says, "I have seen one, whose length did not exceed the fourth of an inch, leap out of a box six inches deep, that is, twenty-four times the length of its own body: others leap a great deal higher." † For this purpose it first erects itself on its tail, which is furnished with two wart-like projections, to enable it to maintain its balance. It then bends itself into a circle, catches the skin near its tail with its hooked mandibles, and after strongly contracting itself from a circular into an oblong form, it throws itself with a jerk into a straight line, and thus makes the leap.

One very surprising provision is remarkable in the breathing-tubes of the cheese-maggot, which are not

Cheese hopper (*Piophila casei*, Fabricius): *c*, the maggot extended; *d*, a leaping position; *f*, the same magnified; *e*, the fly magnified; *g*, the fly, natural size.

* Swammerdam, vol. ii. p. 69.
† Bibl. Nat., vol. ii. p. 65.

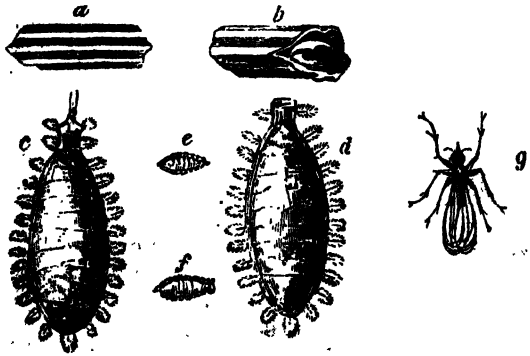
placed, as in caterpillars, along the sides, but a pair near the head and another pair near the tail. Now, when burrowing in the moist cheese, these would be apt to be obstructed; but to prevent this, it has the power of bringing over the front pair a fold of the skin, breathing in the meanwhile through the under pair. Well may Swammerdam denominate these contrivances "surprising miracles of God's power and wisdom in this abject creature."

Like the other destructive insects above mentioned, the multiplication of the cheese-fly is checked by some insect, whose history, so far as we are aware, is not yet known. Swammerdam found many of the maggots with other larvæ in their bodies; but he did not trace their transformations. If they were the larvæ of an ichneumon, it must be exceedingly minute.

It must have attracted the attention of the most incurious, to see, during the summer, swarms of flies crowding about the droppings of cattle, so as almost to conceal the nuisance, and presenting instead a display of their shining corslets and twinkling wings. The object of all this busy bustle is to deposit their eggs where their progeny may find abundant food; and the final cause is obviously both to remove the nuisance and to [illegible] abundant food for birds and other animals, [illegible] upon flies or their larvæ. The same remarks apply [illegible] no less force to the blow-flies which deposit their [illegible] and in some cases their young; upon which [illegible] common house-fly *(Musca domestica)* belongs to the first division, the natural food of its larvæ being horse-dung; consequently it is always most abundant in houses in the vicinity of stables, cucumber beds, &c. to which, when its numbers become annoying, attention should be primarily directed, rather than having recourse to fly-waters.

Another common insect (*Bibio hortulanus*, Meigen) lives in the larva state in cesspools, along with rat-tailed larvæ, &c. The maggot of the bibio is very peculiar in form. They are hatched from eggs with shells as hard as Paris plaster, deposited on the adjacent walls, and

frequently upon the pupa-case which the mother has previously quitted. Like the larvæ of the crane-flies above described, this one moves itself chiefly by means of its mandibles, and therefore it can make no progress on a piece of smooth glass. Its skin, it may be remarked, is so exceedingly hard and tough, that it is no easy matter to kill it.* We have introduced this insect here, however, chiefly for the purpose of refuting an erroneous popular accusation against it, which is supported by the high authorities of Ray and Réaumur. Our great English naturalist calls it the deadliest enemy of the flowers in spring, and accuses it of despoiling the gardens and fields of every blossom.† Réaumur is less decided in his opinion; for though he perceived that, not being furnished with mandibles, they could not, as is supposed, gnaw the buds of fruit-trees; yet, from their being found crowded upon flowers and buds, he thinks they may suck the juices of these, and thus cause them to wither.‡ We are satisfied, by repeated observation, that the fly



Transformations of *Bibio hortulanus*, MEIGEN. *a*, the egg magnified; *b*, the same when hatched; *c*, *d*, the maggot and pupa magnified; *e*, *f*, the same, natural size; *g*, the fly.

* Swammerdam, x. 212.

† Raii Hist. Insect. Præf. p. xi. ‡ Réaumur, v. 56.

only uses its sucker (*haustellum*) for sipping the honey of flowers, or the gum with which the opening bud is usually covered. The damage of which it is accused is more probably done by caterpillars, snails, or other night-feeding insects, which, not being seen by day, the fly is blamed for what it is entirely innocent of. (J. R.)

In the case of the blow-flies Linnæus tells us that the larvæ of three females of *Musca vomitoria* will devour the carcase of a horse as quickly as would a lion; and we are not indisposed to take this literally, when we know that one mother of an allied species (*M. carnaria*) produces about 20,000, and that they have been proved by Redi to increase in weight two-hundred-fold within twenty-four hours. The most extraordinary fact illustrative of the voracity of these maggots which we have met with, is the following, given by Kirby and Spence, from 'Bell's Weekly Messenger:'—

"On Thursday, June 25th, died at Asbornby, Lincolnshire, John Page, a pauper belonging to Silk-Willoughby, under circumstances truly singular. He being of a restless disposition, and not choosing to stay in the parish workhouse, was in the habit of strolling about the neighbouring villages, subsisting on the pittance obtained from door to door: the support he usually received from the benevolent was bread and meat; and after satisfying the cravings of nature, it was his custom to deposit the surplus provision, particularly the meat, betwixt his shirt and skin. Having a considerable portion of this provision in store, so deposited, he was taken rather unwell, and laid himself down in a field, in the parish of Scredington; when, from the heat of the season at that time, the meat speedily became putrid, and was of course struck by the flies: these not only proceeded to devour the inanimate pieces of flesh, but also literally to prey upon the living substance; and when the wretched man was accidentally found by some of the inhabitants, he was so eaten by the maggots that his death seemed inevitable. After clearing away, as well as they were able, these shocking vermin, those who found Page conveyed him to Asbornby, and a surgeon was immediately procured,

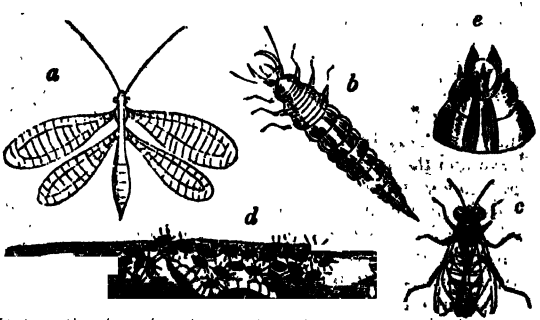
who declared that his body was in such a state, that dressing it must be little short of instantaneous death; and, in fact, the man did survive the operation but a few hours. When first found, and again when examined by the surgeon, he presented a sight loathsome in the extreme; white maggots of enormous size were crawling in and upon his body, which they had most shockingly mangled, and the removing of the external ones served only to render the sight more horrid." Kirby adds, "in passing through this parish last spring, I inquired of the mail-coachman whether he had heard this story; and he said the fact was well known."* The year in which this remarkable circumstance occurred is not mentioned.

The importance of the insects just mentioned, in removing with great rapidity what might otherwise prove nuisances of considerable magnitude, naturally leads us to notice another sort of larva, no less useful in diminishing the numbers of the plant-lice (*Aphides*) which do so much damage to cultivated vegetables. We do this also the more readily, that these very insects, which are so beneficial to the husbandman and the gardener, are often erroneously accused of being themselves the cause of the mischief. A correspondent of the Natural History Magazine, for example, says, "the lady-bird is remarkably abundant this season. The shrimp (*larva*) of this insect destroys both turnips and peas in many parts of England."† The truth is, however, that all the species of lady-birds (*Coccinellidæ*, LATR.), both in the larva and the perfect state, feed exclusively on aphides, and never touch vegetable substances. The eggs are placed in a group of twenty or more upon a leaf [illegible] aphides abound; and when the young are hatched themselves [illegible] the aphides of their prey. There [illegible] derable number of species of this family (Mr. [illegible] enumerates fifty);‡ but [illegible] haps, is the seven-spotted lady-bird (*Coccinella septempunctata*), whose larva is of considerable size, and of

* Intr. i. 140, and note.

course, when abundant, must destroy a vast number of aphides.

The maggots of many species of a beautiful family (*Syrphidæ*, LEACH) of two-winged flies are also voracious devourers of the aphides. These larvæ are of a tapering form, and they can contract or lengthen their bodies to a considerable extent; while they have a retractile instrument, armed with three prongs like a trident, with which they transfix their helpless and hapless victims. "When disposed to feed," says Kirby, "he fixes himself by his tail, and being blind, gropes about on every side, as the Cyclops did for Ulysses and his companions, till he touches one, which he immediately transfixes with his trident, elevates into the air, that he may not be disturbed with its struggles, and soon devours. The havoc which these grubs make amongst the aphides is astonishing. It was but last week that I observed the top of every young shoot of the currant trees in my garden curled up by myriads of these insects. On examining them this day, not an individual remained; but beneath each leaf are three or four full-fed larvæ of aphi-



a, Lace-winged fly; *b*, the grub of the same, magnified; *c*, *syrphus*; *d*, larva of the same devouring the aphides of the alder; *e*, the head magnified, to show the mouth.

divorous flies surrounded with heaps of the skins of the slain, the trophies of their successful warfare."*

The larvæ of the lace-winged flies (*Hemerobidæ*, LEACH) are even more destructive to the aphides than either of the preceding; insomuch that Réaumur was induced to call them the lions of the aphides. The mandibles of the larva of Hemerobius are somewhat crescent-shaped, and, like those of the ant-lion, are hollow, by means of which they suck the juices of their victims. These are rarely so numerous as the two preceding families, but they make up for their fewness in the voracity with which they devour the little destroyers of our vegetables.

II.—ON THE COLLECTION AND PRESERVATION OF INSECTS FOR THE PURPOSES OF STUDY.

"I could wish," says Addison, in 'The Spectator,' "our Royal Society would compile a body of natural history, the best that could be gathered together from books and observations. If the several writers among them took each his particular species, and gave us a distinct account of its original, birth, and education; its policies, hostilities, and alliances; with the frame and texture of its inward and outward parts,—and particularly those which distinguish it from all other animals,—with their aptitudes for the state of being in which Providence has placed them; it would be one of the best services their studies could do mankind, and not a little redound to the glory of the All-wise Creator."* Now, though we can scarcely consider Addison as a naturalist, in any of the usual meanings of the term, it would be no easy task, even for those who have devoted their undivided attention to the subject, to improve upon the admirable plan of study here laid down. It is, moreover, so especially applicable to the investigation of insects, that it may be more or less put in practice by any person who chooses, in whatever station or circumstances he happens to be placed. Nay, we will go farther; for since it agrees with experience and many recorded instances that individuals have been enabled to investigate and elucidate particular facts, who were quite unacquainted with systematic natural history, we hold it to be undeniable that any person of moderate penetration, though altogether unacquainted with what

* 'Spectator,' No. 111.

is called Natural History, who will take the trouble to observe particular facts and endeavour to trace them to their causes, has every chance to be successful in adding to his own knowledge, and frequently in making discoveries of what was previously unknown. We adverted in a former volume to the spider, which M. Pélissan, while a prisoner in the Bastille, tamed by means of music;* and in another place we quoted some observations on hunting-spiders, by the celebrated Evelyn, both of which are strong proofs of our position, and show that though books are often of high value to guide us in our observations, they are by no means indispensable to the study of nature, inasmuch as the varied scene of creation itself forms an inexhaustible book, which "even he who runneth may read." It shall be our endeavour, therefore, in what we shall now add, to point out a few particulars by way of assisting young naturalists to read the book of nature with the most advantage. It will be of the utmost importance, in the study here recommended, to bear in mind that an insect can never be found in any situation, nor make any movement, without some motive, originating in the instinct imparted to it by Providence. This principle alone, when it is made the basis of inquiry into such motives or instincts, will be found productive of many interesting discoveries, which, without it, might never be made. With this, indeed, exclusively in view, during an excursion, and with a little attention and perseverance, every walk—nay, every step—may lead to delightful and interesting knowledge.

In accordance with these views, we advise the young naturalist to watch as far as possible the progress of every insect which he may meet with, from the egg till its death, marking its peculiar food, the enemies which prey on it, and the various accidents or diseases to which it may be liable,—the latter appearing, to our limited comprehension, to be some of the means appointed by Providence to restrain excessive multiplication. It is

* See Antoine, Animaux Célèbres, t. 24.

obvious that all this may be done (it actually has been done by an illiterate labourer at Blackheath) without knowing the name of the insect observed, or the rank it holds in any particular system. These, however, it may be interesting for the observer to ascertain afterwards, in order that he may compare his own observations with those of other naturalists. At the commencement, therefore, of such investigations, it may be useful, when the name of an insect is unknown, to mark it with some number by way of distinction, till the name (if it have one) given it by systematists be discovered. In our own researches we have found these numeral names—1, 2, 3, or A, B, C,—of considerable use, when we could not readily trace the names we wanted amongst the almost interminable synonymes to be met with in systems of classification.

If we should be asked, what is the best place to find insects, our answer must be, everywhere—woods, fields, lanes, hedge-rows, gardens: wherever a flower blooms or a green leaf grows, some of the insects which feed on living vegetables will be sure to be found, as will those which feed on decaying leaves and decaying wood be met with wherever these abound. In the waters, again, both running and stagnant, from the rill to the river, and from the broad lake to the little pool formed in a cow's footstep, aquatic insects of numerous varieties may be seen. Winged insects, of countless species, may be seen in the air during their excursions in search of food, or for the purposes of pairing or depositing their eggs, and the observation of these forms a most interesting branch of the study. The species which prey on animal substances, either living or dead, often possess such habits as may deter some students from attending to them, and yet they fulfil most important purposes in nature, and have furnished the distinguished naturalists, Redi, Swammerdam, Leeuwenhoeck, Réaumur, and De Geer, with highly interesting subjects of research. The history of many of these animals becomes highly interesting, from its relation to our domestic comfort. The house-fly, for instance, is said to breed amongst

horse-dung; but that its maggots find food in other substances not hitherto ascertained, is rendered probable by the enormous numbers which are sometimes seen at a distance from places where they could obtain the alleged nutriment, as in Pitcairn's Island in the Pacific Ocean,* where there never was a horse. With reference to husbandry, again, the correct history of many insects is perhaps still more important, of which we beg leave to give one striking instance in the case of what is called the turnip-fly (*Haltica Nemorum*, ILLIGER), which is not a fly, but a small jumping-beetle. "In these circumstances," says Mr. W. Greaves, "I flatter myself will be found the cause of the disease here mentioned: the manure which is taken from the farm-yard, and spread upon the soil already cleared for turnips, is afterwards turned in with the plough; the seed is then put in, and nature does not rest till it is time for hoeing. Now, it must be obvious that manure put into the ground at this season of the year (June) must be full of eggs of flies, which are seen to swarm upon manure heaps in the autumnal season, and there deposit their eggs for future generations in the succeeding years. These eggs are hatched by the heat of the sun, when the manure is laid upon the ground, or by the warmth of the earth when it is ploughed in, and make their first appearance in the shape of a caterpillar, which may be observed jumping and crawling on the land. The leaves of vegetables are their choicest food, and in turnip land, though they find nothing else, they find plenty of leaf, and on this they feed to the absolute ruin of the root."† But had this writer taken the trouble to confine these dung maggots under a gauze cover till they were hatched, he would have found, instead of the halticæ, some common two-winged flies, which a simple experiment would have convinced him do not eat green leaves of any kind, being incapable thereof for want of eating-organs; and our young naturalists who may wish to try

* Beechey's Voyage to the Blossom.

† Treatise on Agriculture.

this will be enabled to prove to any farmer, who is in fear of diffusing injurious insects by manure, that no insects bred in dung ever touch a green leaf.

This remark brings us directly back to our subject of instructing the student how to keep such insects as he may find, in order to study their economy. In the case of those just mentioned, which live in dung, in decayed vegetables, or in earth, when they cannot climb upon glass, we have found that open ale-glasses or common tumblers filled with the materials among which they are found, and kept in a due state of moistness, constitute the best apparatus; for even when the animals dig down, their movements can usually be observed through the sides of the glass. In the case of the meal-worm, which lives upon flour, the same expedient answers well, and the whole history of the insect may be read from day to day by simple inspection. We are well aware that it is not common in these collecting days of ours, to take the trouble of breeding any insects besides moths and butterflies; but our design being not to procure specimens, but to ascertain facts, we advise the breeding of every insect whose history it is required to investigate.

In order to succeed in this object, it will be indispensable to place the insects as much as possible in their natural circumstances. Those who breed moths and butterflies to procure specimens, feed them in boxes, into which a branch of the plant each feeds on is placed in a straight-necked phial of water, to keep it fresh. We have found it preferable to give them fresh twice or thrice a day, for the plants kept in water are apt to scour and kill the insects. When we have been unprovided with boxes, we have used ale-glasses or glass tumblers with success, either turning them bottom upwards, and admitting air round the edges by inserting slips of card, or covering them with gauze at top. Such glasses seem to have been the chief apparatus used by Réaumur, Bonnet, and De Geer, in those researches which are quite unrivalled in our own days. Small pasteboard boxes, like those made for ladies' caps, answer very well when covered with gauze.

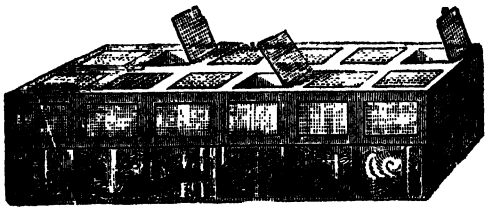
The breeding-cage employed by Mr. Stephens he has thus described:—"The length of the box is twenty inches; height twelve; and breadth six; and it is divided into five compartments. Its lower half is constructed entirely of wood, and the upper of coarse gauze, stretched upon wooden or wire frames; each compartment has a separate door, and is, moreover, furnished with a phial in the centre, for the purpose of containing water, in which the food is kept fresh; and is half-filled with a mixture of fine earth and the dust from the inside of rotten trees, the latter article being added for the purpose of rendering the former less binding upon the *pupæ*,* as well as highly important for the use of such *larvæ* as construct their cocoons of rotten wood. The chief advantages of a breeding-cage of the above description are the occupation of less room than five separate cages, and a diminution of expense, both important considerations when any person is engaged extensively in rearing insects. Whatever be the construction of the box, it is highly necessary that the larvæ be constantly supplied with fresh food, and that the earth at the bottom should be kept damp. To accomplish the latter object, I keep a thick layer of moss upon the surface, which I take out occasionally, perhaps once a week in hot weather, and once a fortnight or three weeks in winter, and saturate completely with water, and return it to its place: this keeps up a sufficient supply of moisture, without allowing the earth to become too wet, which is equally injurious to the pupæ with too much aridity. By numbering the cells, and keeping a register corresponding with the numbers, the history of any particular larvæ or brood may be traced."†

We prefer glass sides to the cells, with gauze doors, opening above, rather than at the sides, according to the following figure. (J. R.)

Some of the beautiful experiments of Bonnet and

* The French naturalists use fine dry sand. See 'Manuel du Naturaliste Préparateur.'

† Ingpen's 'Instructions,' p. 13.



Breeding-cage, with gauze doors and glass sides.

Réaumur suggested to us the idea of supplying insects with growing food, instead either of gathered leaves or branches kept fresh in water; and we have in several instances, particularly in town, where we could not always procure fresh food for our broods when wanted, kept plants growing in garden-pots, and either confined the insects by means of gauze, or surrounded the pots with water, to prevent their escape. We have since carried this somewhat farther, having procured young plants of forest and orchard trees and shrubs, and planted them in garden-pots, which are plunged, as the gardeners term it, to defend them from drought, and are ready for any experiment we choose to make. These, besides, have the advantage of attracting into the garden where the pots are plunged the insects peculiar to the several trees; and when we say that the space occupied is only about thirty or forty feet in length, by two in breadth, while none of the trees are suffered to get above two or three feet high, we apprehend that few persons, who have any garden at all, will find such a plantation unsuitable to their convenience, if they are disposed to such pursuits. Herbaceous plants can, for the most part, be procured and planted at any season they may be required, and hence it is not so necessary to keep any collection of them growing; whereas the transplanting of trees in summer is most likely to kill them. (J. R.)

This plan has, besides, the peculiar advantage of putting it in our power, by means of sufficiently ample

gauze coverings, to make moths, butterflies, and other insects deposit their eggs under our eye on the plants or trees on which they would do so when at liberty,—an interesting part of insect history, which, on account of the difficulties of research, is as yet very imperfectly known.

It would be in vain for us to attempt to enumerate the various plants, trees, and other things on or in which the larvæ or perfect insects should be sought for, as such an enumeration would necessarily be nearly as extensive as the number of known species. A useful little French work, by M. Brez, entitled 'Flore des Insectophiles,' was published about forty years ago, containing a systematic list of plants, with the peculiar insects found on each, and though recent discoveries render it very imperfect, it may still be consulted with advantage. But, with all the information we can procure, the remarks of Addison, in the paper we have quoted, still hold true, that "Seas and deserts hide millions of animals from our observation; innumerable artifices and stratagems are acted in the howling wilderness, and in the great deep, that can never come to our knowledge. Besides, that there are infinitely more species of creatures which are not to be seen without, nor indeed with the help of the finest glasses, than of such as are bulky enough for the naked eye to take hold of. However, from the consideration of such animals as lie within the compass of our knowledge, we might easily form a conclusion of the rest, that the same variety of wisdom and goodness runs through the whole creation, and puts every creature in a condition to provide for its safety and subsistence, in its proper season."*

Looking minutely at all the leaves, flowers, and stems of plants and trees, and prying into every corner where insects may lurk, is one means of discovering their haunts,—the only one, indeed, with respect to many species; but collectors are not satisfied with a process so necessarily slow, and take various means for expediting

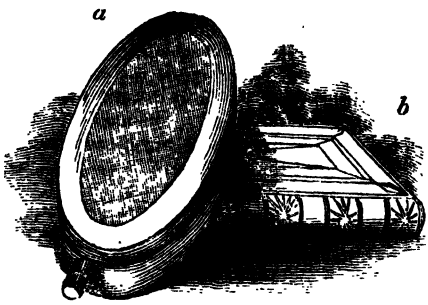
* Spectator, No. 111.

the capture of numbers, rather than observing the natural movements and dispositions of a few. We may advantageously adopt these methods when we wish to furnish our cages with live insects, in order to study their economy.

One of the most useful and handy instruments for this purpose is an umbrella. In walking through a meadow, for instance, where the grass is not too short, we may stretch the umbrella, hold the hollow side uppermost, and push it through the grass, when the insects which may be above its level will fall into the trap. In this way we have procured the caterpillars of saw-flies, moths, and butterflies, which feed on grass and on the other herbage in meadows, where we might probably have searched for them in vain by the eye. The sides of drains and ditch-banks may be trailed in the same manner. The butterfly-nets, to be afterwards described, may be used in the same way, and are, we think, superior to the apparatus invented by Mr. Paul, of Starston in Norfolk, for taking the turnip-fly.

The umbrella is equally useful for holding under the branches of shrubs and trees, which ought to be beaten smartly over it with a strong walking-stick, the shock of the strokes causing the insects to drop down. This, however, will only answer for the smaller and lower branches: when it is required to beat the higher boughs, a long pole must be used, with a sheet or a piece of canvas spread under the tree. The tops of the taller plants may be shaken by the hand over the umbrella.

When insects are thus found, it will be necessary to secure them, in order to take them to the cages uninjured, to be provided with a number of pill-boxes, with pin-holes drilled in them to admit air, and to introduce, particularly along with caterpillars, a bit of the fresh leaf or other substance upon which they have been feeding. We prefer separate, small boxes for such purposes, to the larger larvæ-box in use among collectors; since we can by their means more readily remember the different plants on which several species were found, besides avoiding the risk of one species devouring another,—an

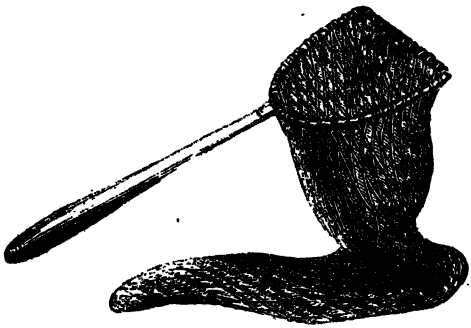


a, Larvæ-box; and *b*, Pocket collecting box.

incident not uncommon among the caterpillars of moths, as we have recorded in a former page. The collector's larvæ-box is an oblong chip box, such as is used for wafers, with a gauze lid for air, and a hole at one end, furnished with a stopper, for introducing the larvæ.

For water-insects a net, similar to a fisher's landing-net, is employed, fixing it to a long pole, and raking with it through every piece of water within reach. The net which we have had constructed consists of an interior lining of gauze, as strong as it can be procured, with a strong fish-net on the outside to strengthen this. When canvas is used, the water does not escape through it with sufficient facility. Many interesting water-insects, however, may be procured by mere inspection of water-plants, particularly the under-sides of their leaves, at the edges of ditches, ponds, canals, rivers, and lakes, and when the water is clear, by examining the bottom of the channel. In consequence of aquatic insects, for the most part, preying upon one another, they are usually very nimble in their movements, so that it requires considerable dexterity and quickness to entrap them. For the same reason a number of phials, containing water, will be as requisite to carry them as pill-boxes to carry the land-insects. But when they are kept in wine or ale-glasses, and supplied with food, they furnish excel-

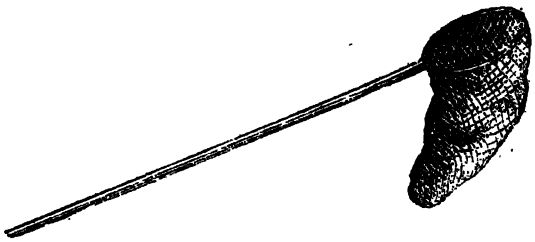
lent materials for interesting observation. It is easy, indeed, in this way to have several successive generations, and when gnats' eggs are procured the whole history of these curious insects may be traced with little difficulty. When the pupæ are observed to be about to be transformed into winged insects, a gauze covering may be employed to prevent their escape.



Water-net.

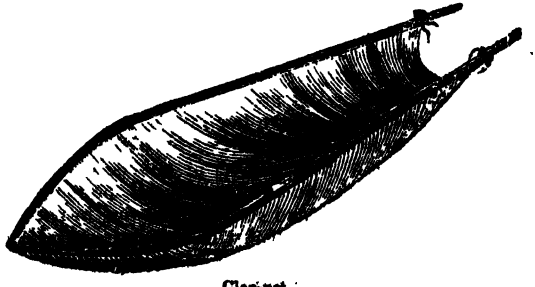
Analogous to the water-net in size and construction is the butterfly-net, which is chiefly used on the Continent, though seldom, we believe, in this country. It consists of a hoop, about a foot in diameter, of brass or iron wire, jointed or not, so as to fold up into a narrow compass, with a bag-net of gauze or thin muslin, two feet deep, attached to it. This is screwed into a pole about six feet long, for ordinary purposes; but for the purple emperor butterfly (*Apatura Iris*), and other high-flying insects, thirty feet is not too long.

The instrument chiefly used for the same purpose in this country is much more unwieldy, though more easily managed by the inexperienced. It is a clap-net, similar to a bird-catcher's bat-fowling-net, but of slighter materials. The rods of the one which we use are about five



Butterfly-net.

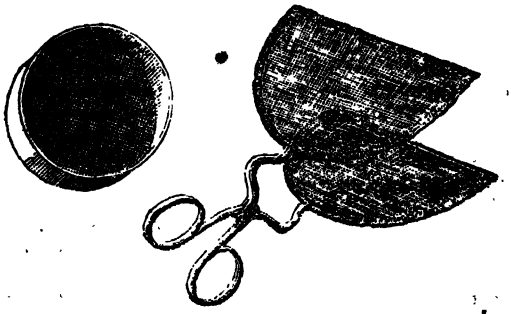
feet long, when the three pieces are joined by means of brass ferules. They ought to be made, tapering like a fishing-rod, of hazel or any tough wood, with two bent pieces of cane at the end, tightly fitted in so as not to slip when the apparatus is used. The net may be made of fine white muslin, for small insects; but green gauze is best for moths and butterflies, the edges being bound with broad tape all round, so as to form a place for the rods to slip in. When the net is mounted, a rod is held in each hand, and the whole spread out so as to intercept insects on the wing, which are secured by clapping the rods together. A little practice will render this easy, except when there is much wind, and in that case few insects fly. It is no less useful for throwing over insects



Clap-net.

when they alight on low flowers, and in this way we have caught some very fine butterflies and moths.

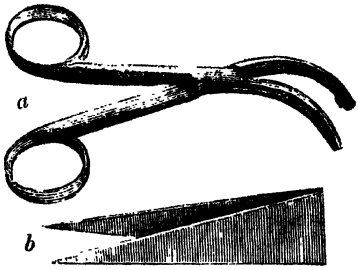
An instrument still more used by collectors than any of the preceding is the net-forceps, which may be readily constructed out of an old pair of curling-irons, such as have rings for the finger and thumb, binding these with silk or cotton to prevent their hurting the hand. To the blades of these, hoops should be fitted, covered with fine gauze, and made to close accurately when moved like a pair of scissors. It requires some experience and dexterity to catch nimble insects with these; but it is indispensable for a collector to acquire this skill. Without



Ring-net. Net-forceps.

opening them at all, the forceps may be used for securing an insect when alighted on a wall, or other flat surface, by merely covering it; for which purpose some collectors also use a ring-net. We are of opinion, however, that it is more convenient to have few instruments, for multiplicity only serves to embarrass.

We have taken a great number of insects by means of a pill-box, putting the lid on one side and the bottom on the other side of a leaf, and suddenly shutting in both the insect and the part of the leaf it was sitting on. When a small moth, again, or other insect, is resting on a wall, a pane of glass, or the smooth trunk of a tree, we take



a, French beetle forceps; and *b*, Pliers.

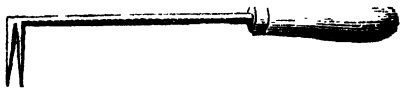
off the lid of a pill-box, cover the insect with the bottom part, which we move backwards and forwards till the insect takes refuge from the annoyance at the very bottom, when we cover it as quickly as possible with the lid. This is by far the best way of taking small moths, for their delicate plumage is not injured, as it must inevitably be when they are touched even in the most gentle way.

We purchased last year, in Paris, a pair of insect forceps, which do not seem to be known to our collectors, but which we have found exceedingly useful for taking beetles and other insects out of holes where they cannot be otherwise easily reached. The instrument is made of steel, and resembles a pair of large scissors. In some, the handle-rings are like those of scissors, on a line with the blades; in others, they are at right angles to these. The pliers used by our collectors are much inferior in utility, being too small, short, and slender. The French instrument is farther useful for seizing venomous or dangerous insects. In other cases the fingers alone are often sufficient, and for minute beetles a wetted finger.

In order to get at beetles and larvæ which feed under the bark, or in the wood of trees, and also under ground, the instrument which we have found most convenient is

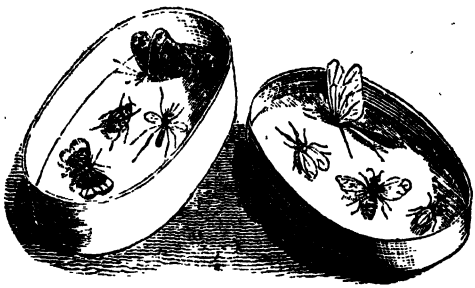
a very strong clasp-knife: one which has a saw-blade, a hook, a file, and other instruments in the same handle, is preferable; but most of the London collectors use what is called a digger, and first, if we mistake not, described by Mr. Samouelle, in his Compendium. It is made of steel, of from twelve to eighteen inches long, forked at the extremity, and fixed into a wooden handle.

In addition to this, we recommend a long slip of very thin and narrow whalebone, which may be introduced into the holes of such insects as burrow in the earth or sand, to direct us in digging down to their nests, the hole being certain to be filled up, and probably lost, without such a contrivance. When a piece of whalebone is not at hand, a long straw will form a good substitute.



Digger.

When insects are caught merely for the cabinet, and not with reference to their habits and economy, collectors provide themselves with a quill-barrel, sealed at one end with wax, and having a cork stopper at the other, for very minute specimens; with a wide-mouthed phial, containing weak spirits of wine, into which dark-coloured beetles, wasps, and bees, are put, the spirits instantly killing them, and preserving them for future purposes; and with a pocket collecting box or boxes for winged insects. An oblong chip wafer-box, lined at top and bottom with cork, and covered with white paper, will form a very good collecting box, taking care that it is neither too shallow nor too deep; but some have a square box, made of mahogany, deal, or cedar, with hinges on one side and a spring on the other, so that it can be opened by the left hand while an insect is held in the right, and figured above (*b*, p. 228). Sparmann, when travelling at the Cape, used to stick his insect specimens on the outside of his hat, to the consternation of the



Chip collecting box, opened.

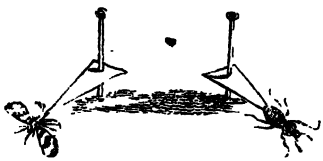
simple Hottentots, who took him for a conjuror. A more judicious plan is for a collector to have the crown of his hat lined inside with cork, which will save him the trouble of carrying a collecting box. When a collector has not his boxes with him, a bit of paper, twisted at each end, will often answer every purpose.

When an insect is caught, before it be placed in the collecting box or the hat-crown, it is necessary to kill it, and this circumstance has given rise to much prejudice, on the charge of cruelty,—the objectors forgetting that most of the insects so killed could not naturally survive many days, and that their feelings of pain are, in all probability, much less acute than those of animals furnished with a brain and cerebral and vertebral nerves, of which they are destitute. Accordingly, a fly without its head will walk about almost as if nothing had happened to it, and a wasp will eat greedily with the head only when it has been separated from the body. We should not like, however, to be considered advocates of any species of cruelty, however slight, and in killing insects for a collection the speediest methods are to be preferred. In the case of butterflies and some moths, as well as other winged insects, a slight pressure upon the breast will instantly kill them, and exposing them to heat is a still more rapid means, plunging those con-

tained in a phial into boiling water, and holding those in pill-boxes near the fire. Suffocating them with sulphur, as some recommend, spoils the colours; and we remarked in the museums of Brussels, Louvain, and Frankfort-on-the-Maine, that all the insects had had their colours injured in this way, the black spots on white butterflies being turned to brown, and the white tinged with yellowish green. In the case of insects tenacious of life, such as some moths, particularly females which have not

Setting-needles and brush; with the method of setting insects. *a*, Swallow-tailed butterfly (*Papilio machaon*); *b*, Wasp; *c*, Beetle.

deposited their eggs, piercing their breast with a pin dipt in nitric acid will instantly kill them. After killing dragon-flies the intestines must be carefully removed, otherwise the colours will all become black.



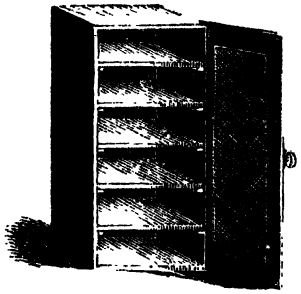
Method of mounting small insects.

To fit insects for a cabinet, they require to be *set*, as it is termed; that is, all their parts must be placed in the manner best fitted to display them. For this purpose each is pierced, when dead, with an insect pin, a fine slender sort, manufactured on purpose. Beetles ought to have the pins passed through the shoulder of the right wing-case, and butterflies and other insects through the corslet, on a right line with the head, and a little back from it. While the insect is fresh and flexible, the legs and wings are to be stretched out with a setting-needle, or a large pin bent at the point and fixed into a wooden handle, then stuck upon a board covered with cork and paper, and kept in their proper position by means of pins and braces till they become dry and stiff. The braces are made with slips of fine card, or thick hot-pressed paper, stuck through at one end with a strong pin. When insects have become stiff before being set, they may be rendered flexible again by covering them over for several hours with a damp cloth, which, however, must not be permitted to touch them. A camel-hair pencil is used for brushing off dust. The mode of setting will be best understood from the figures.

When insects are very small, as piercing them with a pin would destroy them, it is usual to gum them on a slip of card or cut wafer, and to arrange this in the cabi-

net. Minute beetles and flies may thus be preserved, as is shown in the figures.

The setting-board ought to be kept where there is a free ventilation of air till the set insects are thoroughly dry; but it is necessary that it be also out of the reach of spiders; for we have in several instances had our specimens, while drying, mutilated and destroyed by these prowlers. The most convenient apparatus is an upright box, with grooves, into which the setting-boards may slide, with the door and the side of the box opposite to it covered with gauze.



Setting-board frame.

No other preservative is wanted, after the insects are set and dried, except to keep them from damp, to put a little camphor in the cabinet drawers to prevent mites, and to take care to prevent them from being destroyed by the larvæ of some small moths and beetles, which the camphor will not do, nor anything else with which we are acquainted. We had once a whole drawer of insects destroyed by mice. Glazing the drawers of a cabinet, and occasional careful inspection, will be indispensable to keep a collection in good condition.

The cabinet may consist of more or fewer drawers, according to the extent of a collection. The most convenient dimensions of the drawers are from a foot to

eighteen inches square, and two inches deep; and the best wood is mahogany, cedar, or wainscot, deal being apt to split or warp. The doors ought to have velvet glued round the edges, to keep out dust and small insects. The bottoms of the drawers are lined with sheet cork, about a sixth of an inch in thickness, made uniformly smooth by filing, and having white paper pasted over it.

Where a cabinet has not been procured, collectors make use of store boxes, made on the principle of a backgammon board, each leaf being about two inches deep, and lined with cork and paper. These are convenient, also, for travellers sending home insects from a distance.

The specimens are best arranged in columns from top to bottom of the drawers, with the names attached to each. We are unwilling, amidst the great variety of systems, to recommend any particular one as the best; and prefer leaving our readers to choose for themselves, by giving the outlines of the principal classifications which have been proposed from the earliest times till the present day.

III.--SYSTEMATIC ARRANGEMENTS OF INSECTS.

When we consider that the number of known species of British insects alone amounts to more than ten thousand, being about six times more than the species of our plants—that is, six species of insects, on an average, to each species of plant—it will be obvious that, in a collection of specimens, some systematic order of arrangement will be requisite; though, for purposes of out-door study of manners and economy, nice distinctions are less indispensable, as appears from the beautiful and successful researches of Réaumur, Gould, Lyonnet, Bonnet, the Hubers, and other distinguished inquirers, who paid little or no attention to the minutiæ of classification. In consequence, however, of a course diametrically opposite having been pursued by other naturalists of celebrity, we consider it our duty to warn our readers against the error of considering arrangement the sole end and aim of study; whereas the correct view of the matter, as we understand it, is not to neglect or discard system, as was done by Réaumur and Bonnet, but to make it subservient to such details of causes, motives, and effects, as we have endeavoured to exemplify. In every page of these volumes we have accordingly kept systematic distinctions closely, though subordinately, in view. We shall now give a brief sketch of several classifications of insects, invented by celebrated writers, from the earliest times.

The Wing System.

The illustrious Aristotle, almost the only genuine naturalist among the ancients, seems to have been the first who distinguished insects by their wings,—a principle followed with greater minuteness, in recent times, by Linnæus and De Geer. Aristotle does not, indeed, put his system in a tabular form; but, for the sake of brevity, we shall draw up a table, founded on indications in his admirable History of Animals.

Aristotle's Classification.

I. Winged Insects (*Pterota*, or *Ptilota*).
1. With wing-cases—beetles—(*Coleoptera*).
2. With coriaceous wings—grasshoppers (*Pedetica*).
3. Without jaws—bugs (*Astomata*).
4. With powdery wings—moths and butterflies (*Psychæ*).
5. With four transparent wings (*Tetraptera*).
   Without stings, and larger—dragon-flies.
   With stings—bees and wasps (*Opisthocentra*).
6. With two wings (*Diptera*).
   Without mouth-piercers, and smaller — flies and crane-flies.
   With mouth-piercers—gnats and gad-flies (*Emprosthocentra*.

II. Wingless Insects.
1. Occasionally acquiring wings:—
   Ants (*Myrmices*).
   Glow-worms (*Pygolampides*).
2. Without wings (*Aptera*).

Linnæus's Classification.

I. Winged Insects.
1. *With four wings:—*
   a, Upper wings more or less crustaceous: the under wings membranaceous.

Upper wings quite crustaceous, and not overlapping—beetles (*Coleoptera*).
Upper wings semi-crustaceous, and overlapping—bugs and grasshoppers (*Hemiptera*).
b, Upper and under wings of the same texture.
Wings covered with small tiled scales—butterflies and moths (*Lepidoptera*).
Wings membranaceous and naked.
Without a sting—dragon-flies, &c. (*Neuroptera*).
With a sting—wasps, bees, &c. (*Hymenoptera*).
2. *With two wings:*—Flies, gnats, &c. (*Diptera*).

II. WINGLESS INSECTS (*Aptera*).

De Geer's Classification.

I. WINGED INSECTS.

1. *Wings four, without wing-cases:*—
a, Wings covered with scales; tongue spiral—butterflies and moths.
b, Wings naked and membranaceous—May-flies and caddis-flies.
c, Wings equal, membranaceous, and netted; the mouth with teeth—dragon-flies and lace-winged flies.
d, Wings unequal; nervures placed lengthwise; mouth with teeth; and the females having a sting or ovipositor—bees, wasps, ants, ichneumons, saw-flies, &c.
e, Wings membranaceous; the tongue bent under the throat—tree-hoppers, &c.
2. *Wings two, covered by two wing-cases:*—
a, Wing-cases partly coriaceous and partly membranaceous, overlapping each other; tongue bent under the throat—bugs, &c.
b, Wing-cases coriaceous, or somewhat crustaceous and wing-like, overlapping; mouth with teeth—locusts, crickets, and grasshoppers.
c, Wing-cases hard and crustaceous, not overlapping, covering the under wings; mouth with teeth—beetles.
3. *Wings two, without wing-cases:*—
a, Two membranaceous wings, and two poisers be-

hind these; mouth with a tongue, but no teeth —flies, gnats, &c.

b, Two membranaceous wings in the male, but no poisers, tongue, nor teeth; no wings in the female, but a tongue in the breast—vine-louse, &c.

II. WINGLESS INSECTS.

1. *Undergoing transformation*:—
With six legs, and the mouth having a tongue—fleas.
2. *Undergoing no transformations*:—
a, With six legs, the head distinct from the trunk— —white ants, &c.
b, With eight or ten legs, and the head not distinct from the trunk—spiders, crabs, &c.
c, With fourteen or more legs, and the head distinct from the trunk—centipedes, wood-lice, &c.

THE LOCALITY SYSTEM.

THE next system, in order of time, reckoning from the period of Aristotle, is taken, not from the structure of insects, but the places they frequent. We owe the first sketch of an arrangement on this principle to the great naturalist of Italy, Ulysses Aldrovand, whom it has been the recent fashion to decry as a collector of fables; but whose voluminous works, written in Latin, and never, we believe, translated, must always be consulted with admiration by every genuine inquirer, as a mine of information altogether miraculous as the production of one man.

Aldrovand's Classification.

I. LAND INSECTS (*Terrestria*).

1. *With feet* (Pedata):—
a, With wings (*Alata*).
Without wing-cases (*Anelytra*).
With membranaceous wings (*Membranacea*).
Honey-making (*Favifica*).
Not honey-making (*Non favifica*).

With scaly wings (*Farinosa*).
With wing-cases (*Elytrota*).
b, Without wings (*Aptera*).
With few feet (*Paucipeda*).
With many feet (*Multipeda*).
2. *Without feet* (Apoda).

II. Water Insects (*Aquatica*).
1. *With feet* (Pedata) :—
a, With few feet (*Paucipeda*).
b, With many feet (*Multipeda*).
2. *Without feet* (Apoda).

Vallisnieri's Classification.

I. Plant Insects (*Insetti, che annidano nelle pianti e le divorano*).
II. Water insects (*Insetti, che nuotano, crescono, vivono, e sempre dimorano ne' soli fluidi*).
III. Insects inhabiting Earthy or Mineral Substances (*Insetti, che si trovano dentro i marmi, sassi, crete, ossa, e conchiglie*).
IV. Insects inhabiting Living Animals (*Insetti, che fanno dentro, o sopra i viventi* *).

Fabricius's Geographical Classification.

This celebrated systematic writer divides the globe into eight insect climates :—

1. Indian.
2. Egyptian.
3. Southern.
4. Mediterranean.
5. Northern.
6. Oriental.
7. Occidental.
8. Alpine.

Latreille's Geographical Classification.

This celebrated French systematist has written a curious and ingenious paper on the Geography of Insects, as a companion to Humboldt's famous Geography of Plants. He divides the globe into twelve insect zones or climates, thus :—

* Esperienze ed Osservazioni, p. 42, 43 ; 4to., Padova, 1726.

I. ARCTIC, all North of the Equator.

1. Polar.
2. Sub-polar.
3. Superior.
4. Intermediate.
5. Supra-tropical.
6. Tropical.
7. Equatorial.

II. ANTARCTIC, all South of the Equator.

1. Equatorial.
2. Tropical.
3. Supra-tropical.
4. Intermediate.
5. Superior.

Connected with this subject is the doctrine of *Representation* and *Replacement*, by which it is maintained, that when a particular species of insect, or other animal, is not found in two several countries or districts, such as Britain and New England, it is represented or replaced by some species resembling it in form and in function. Taking a more popular example than insects furnish, it is held, according to this system, that the puma of America *replaces* the lion of Africa, or that the pecari *represents* in Mexico the hog of Europe.

THE TRANSFORMATION SYSTEM.

THERE are considerable differences in transformations among various species. These, the illustrious Swammerdam, whose accurate observations are now as valuable as when they were made nearly two centuries ago, has made the basis of his system.

Swammerdam's Classification.

I. Transformations immediate, the insects being hatched perfectly formed—fleas, spiders, &c.

II. Transformations taking place under a covering*—locusts, crickets, bugs, dragon-flies, May-flies, &c.

III. Transformations with a pupa-case intermediate*—beetles, bees, wasps, saw-flies, gnats, &c.

* In explaining Swammerdam's system, Kirby and Spence use the terms of "complete" and "incomplete," which are not in the original.

Transformations in the pupa state obtected—moths and butterflies.

IV. Transformations in the pupa state coarctate—ichneumons, flies, &c.

Ray and Willughby's Classification.

I. INSECTS UNDERGOING NO TRANSFORMATIONS (Αμεταμορφωτα).

1. *Without feet* (Αποδα):—
   a, Land Insects, including worms, &c. (*Terrestria*).
   b, Water Insects, including Leeches, &c. (*Aquatica*).
2. *With feet* (Pedata):—
   a, With six feet (*Hexapoda*).
   Land Insects (*Terrestria*).
   Larger, including lignivorous larvæ (*Majora*).
   Less, including lice and springtails (*Minora*).
   Water Insects, including the river shrimp (*Aquatica*).
   b, With eight feet (*Octopoda*).
   With tails—scorpions (*Caudata*).
   Without tails—spiders, mites (*Non caudata*).
   c, With fourteen feet—woodlice (Τεσσαρεσκαιδεκαποδα).
   d, With twenty-four feet.
   e, With thirty feet.
   f, With many feet (Πολυποδα).
   Land Insects (*Terrestria*).
   With a roundish body—millepedes (*Tereti* seu *subrotundi*).
   With a flat or compressed body—centipedes (*Plano* seu *compressa*).
   Water Insects (*Aquatica*).
   With a round body (*Corpore tereti*).
   With a flat body (*Corpore plano*).
   With a double tail (*Bicaudatum*).

II. INSECTS UNDERGOING TRANSFORMATIONS (Μεταμορφουμενα).

1. *Transformations instantaneous* (Transmutatio instantanea):—
   a, Lace-winged flies (*Libellæ* seu *Perlæ*), &c.
   b, Wild bugs (*Cimices sylvestres*).
   c, Locusts and mantes (*Locustæ*).

d, Field-crickets (*Grylli campestres*).
e, Hearth-crickets (*Grylli domestici*).
f, Mole-cricket (*Gryllo talpa*).
g, Tree-hoppers (*Cicadæ*).
h, Cock-roaches (*Blattæ*).
i, Crane-flies (*Tipulæ*).
k, Water-scorpion (*Scorpius aquaticus*).
l, Water-flies (*Muscæ aquaticæ*).
m, May-flies (*Hemerobii*).
n, Ear-wigs (*Forficula* seu *auricularia*).

2. *Transformations two-fold* (Metamorphosis duplex):—
a, With wing-cases—beetles (Κουλεοπτερα seu *Vaginipennia*).
b, Without wing-cases (Ανελυτρα).
With mealy wings—butterflies and moths (*Alis farinaceis*).
With membranaceous wings—bees, flies (*Alis membranaceis*).
With two wings (Διπτερα).
With four wings (Τετραπτερα).
Gregarious (*Gregaria*).
Making honey—bees, &c. (*Mellifica*).
Not making honey (*Non mellifica*).
Solitary (*Solitaria*).
Bee-formed (*Apiformia*).
Wasp-formed (*Vespiformia*).
Butterfly-formed (*Papilioniformia*).
With an ovipositor (*Seticaudæ* seu *Tripilia*).

The Cibarian, Maxillary, or Mouth System.

Fabricius, a Danish systematic writer of high celebrity, emulous of the fame of Linnæus, conceived the idea of classifying insects according to the structure of their mouths, or their feeding organs (*Instrumenta cibaria*).

Fabricius's Classification.

A.

1. With the lower jaws naked, free, and carrying palpi—beetles (*Eleutherata*).
2. With the lower jaws covered by an obtuse shield or lobe—locusts, crickets, &c. (*Ulonata*).
3. With the lower jaws jointed at the base, and joined with the lip—lace-wing flies, &c. (*Synistata*).

4. With the lower jaws horny, compressed, and often elongated—bees, wasps, &c. (*Piezata*).
5. With the lower jaws horny, toothed, and having two palpi—dragon-flies, &c. (*Opontata*).
6. With the lower jaws horny, vaulted, and no palpi—centipedes, wood-lice, &c. (*Mitosata*).

B.

7. With the lower jaws horny, and armed with a claw—spiders, &c. (*Unogata*).

C.

8. With many jaws within the lip, the palpi mostly six (*Polygonata*).
9. With many jaws, without the lip closing the mouth (*Kleistagnatha*).
10. With many jaws without the lip, covered by palpi (*Exochnata*).

D.

11. Mouth with a spiral tongue, between reflected palpi—butterflies and moths (*Glossata*).
12. Mouth with a rostrum and a jointed sheath—bugs, &c. (*Ryngota*).
13. Mouth with a sucker without joints—flies, &c. (*Antliata*).

Cuvier's Classification.

I. INSECTS WITH JAWS.

1. Without wings—crabs, spiders (*Guathoptera*).
2. With four equal wings—dragon-flies, &c. (*Neuroptera*).
3. With four unequal wings—bees, wasps (*Hymenoptera*).
4. With wing-cases—beetles (*Colcoptera*).
5. With four straight wings—crickets, &c. (*Orthoptera*).

II. INSECTS WITHOUT JAWS.

1. With upper wings of unequal consistence—bugs, &c. (*Hemiptera*).
2. With powdery wings—butterflies and moths (*Lepidoptera*).
3. With two wings—flies, &c. (*Diptera*).
4. Without wings—fleas, mites, &c. (*Aptera*).

Lamarck's Classification.

I. INSECTS WITH JAWS.

1. With wing-cases—beetles (*Coleoptera*).
2. With straight wings—crickets, &c. (*Orthoptera*).
3. With four equal wings—dragon-flies (*Neuroptera*).

II. INSECTS WITH JAWS AND A SORT OF SUCKER.

4. With four unequal wings—bees, &c. (*Hymenoptera*).

III. INSECTS WITH NO JAWS, BUT HAVING A SUCKER.

5. With powdery wings—moths, &c. (*Lepidoptera*).
6. With upper wings of unequal consistence—bugs, &c. (*Hemiptera*).
7. With two wings—flies, &c. (*Diptera*).
8. Without wings (*Aptera*).

THE OVARY, OR EGG SYSTEM.

IT has been recently proposed to arrange all animals according to the structure, &c. of their eggs (*ova*); and, in accordance with this principle, an ingenious arrangement has been constructed by a venerable and enthusiastic inquirer, from which we shall give what relates to certain insects forming the eighth class.

Sir Everard Home's Classification.

METAMORPHOGENOA,

Having the embryo produced from an egg which is formed in the ovarium, subjected to transformation, and breathing by air-tubes (*spiracula*); heart wanting; blood white.

1. The embryo developed from eggs attached under the tail. Lobster (*Cancer*).
2. The embryo developed from eggs carried upon the anterior feet. Spider (*Aranea*).
3. The embryo developed from eggs deposited under the cuticle of the skin or stomach. Gad-fly (*Œstrus*).
4. Embryos developed from eggs for several generations, impregnated at the same time. Plant-louse (*Aphis*).
5. Embryos, produced from eggs of one mother, that compose the whole republic. Bee (*Apis*).
6. Embryos from eggs deposited under water. The water-moth (*Phryganea*).

The Eclectic, or Modern System.

M. Clairville appears to have first conceived the idea of uniting the principles of several of the preceding systems, an idea which has been followed up by Latreille, Dr. Leach, and Mr. Stephens.

Clairville's Classification.

I. Winged Insects (*Pterophora*).
1. *With jaws* (Mandibulata):—
   a, With wing-cases (*Elytroptera*).
   b, With coriaceous wings (*Deratoptera*).
   c, With netted wings (*Dictyoptera*).
   d, With veined wings (*Phleboptera*).
2. *With suckers* (Haustellata):—
   a, Wings with poisers (*Halteriptera*).
   b, Wings powdery (*Lepidoptera*).
   c, Wings partly opaque and partly translucent (*Hemimeroptera*).

II. Wingless Insects (*Aptera*).
1. With a sucker (*Haustellata*).
   With a sharp sucker (*Rophoptera*).
2. With jaws (*Mandibulata*).
   With legs formed for running (*Pododunera*).

*Latreille's Classification.**

I. Insects with more than Six Feet, and without Wings (*Myriapoda*).
1. *With many jaws*—wood-lice (*Chilognatha*).
2. *With many feet*—millepedes (*Chilopoda*).

II. Insects with Six Feet.
Without wings:—
   a, With organs of motion like feet (*Thysanura*).
   b, Mouth with a retractile sucker (*Parasita*).
   c, External mouth with a jointed tube enclosing a sucker (*Suctoria*).
With four wings:—
   A, Upper wings crustaceous or coriaceous, at least at the base.

* Règne Animal, 8vo. Paris, 1829.

a, With the under wings folded crosswise—beetles (*Coleoptera*). 1. Pentamera; 2. Heteromera; 3. Tetramera; 4. Trimera.
b, With the under wings folded lengthwise (*Orthoptera*).
Legs formed for running (*Cursoria*).
Legs formed for leaping (*Saltatoria*).
c, With a sucker enclosing several bristles (*Hemiptera*). 1. Heteroptera; 2. Homoptera.
B, Upper wings membranaceous.
a, Wings naked and netted (*Neuroptera*). 1. Subulicornes; 2. Planipennes; 3. Plicipennes.
b, Wings naked and veined (*Hymenoptera*). 1. Terebrantia; 2. Aculeata.
c, Wings with dust-like scales (*Lepidoptera*). 1. Diurna; 2. Crepuscularia; 3. Nocturna.
With two twisted elytra and two wings (Rhipiptera). 1. Xenos; 2. Stylops.
With two wings (Diptera).

Leach's Classification.

I. INSECTS UNDERGOING NO TRANSFORMATION (*Ametabolia*).

1. With bristles at the tail (*Thysanura*).
2. With no bristles at the tail (*Anoplura*).

II. INSECTS UNDERGOING TRANSFORMATION (*Metabolia*).

1. With two wings folded crosswise, and covered with hard wing-cases (*Coleoptera*).
2. With two wings folded lengthwise and crosswise, and short and softer wing-cases (*Dermaptera*).
3. With two wings folded lengthwise and wing-cases overlapping each other at the edges (*Orthoptera*).
4. With two wings twice folded lengthwise, and wing-cases obliquely overlapping; mouth with jaws (*Dictyoptera*).
5. With two wings, and overlapping wing-cases, having the apex membranaceous (*Hemiptera*).
6. With two wings, and coriaceous or membranaceous wing-cases (*Omoptera*).
7. With no wings nor wing-cases (*Aptera*).

8. With four wings covered with meal-like scales (*Lepidoptera*).
9. With four membranaceous wings, the wingbones hairy (*Trichoptera*).
10. With four nearly equal membranaceous reticulated wings (*Neuroptera*).
11. With four unequal membranaceous wings, the wingbones running lengthwise (*Hymenoptera*).
12. With two wings folded lengthwise (*Rhipiptera*).
13. With two wings not folded; mouth formed for sucking—flies (*Diptera*).
14. With two or with no wings; mouth with long jaws—bird-flies, bat-flies (*Omaloptera*).

Stephens's Classification.

I. INSECTS WITH MANDIBLES (*Mandibulata*).

1. With hard wing-cases (*Coleoptera*).
   a, Voracious (*Adephaga*).
   Ground feeders (*Geodephaga*).
   Water feeders (*Hydrodephaga*).
   b, Cleansers (*Rypophaga*).
   Haunting water (*Philhydrida*).
   Feeding on carrion, or putrid wood (*Necrophaga*).
   With short wing-cases (*Brachelytra*).
   c, Chilognathiform larvæ.
   With clavate sublaminate antennæ (*Helocera*).
   With laminate antennæ (*Lamellicornes*).
   With filiform antennæ (*Sternoxi*).
   With setaceous or abruptly clavate antennæ.
   d, Vermiform larvæ.
   With a rostrum (*Rhinchophora*).
   Without a rostrum (*Longicornes*).
   e, Anopluriform ? larvæ.
   Tarsi tetramerous.
   Body elongate (*Eupoda*).
   Body ovoïd or oval (*Cyclica*).
   Tarsi trimerous (*Trimeri*).
   f, Heteromerous beetles (*Heteromera*).
2. With short and somewhat crustaceous wing-cases—earwigs (*Dermaptera*).
3. With coriaceous wing-cases (*Orthoptera*).
4. With netted wings (*Neuroptera*).
   a, Scorpion-flies (*Panorpina*).

b, Day-flies (*Anisoptera*).
c, Dragon-flies (*Libellulinę*).
d, White-ants (*Termitina*).
e, With large wings (*Megaloptera*).
5. With four hairy wings (*Trichoptera*).
6. With four unequal wings (*Hymenoptera*).
a, Borers (*Terebrantia*).
b, ——— wasps, bees, ants, &c.
c, ——— ruby tails, &c.
7. ——— stylops (*Strepsiptera*).

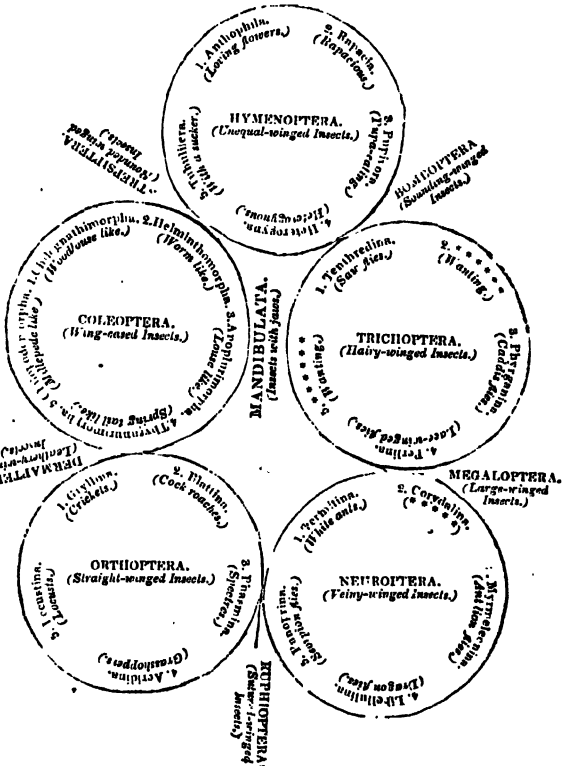
II. INSECTS WITH SUCKERS (*Haustellata*).

1. With powdery wings (*Lepidoptera*).
a, Butterflies appearing by day (*Diurna*).
b, Moths appearing at twilight (*Crepuscularia*).
c, Moths appearing in the afternoon (*Pomeridiana*).
d, Moths appearing at night (*Nocturna*).
e, Moths appearing partly by day (*Semidiurna*).
f, Moths appearing in the evening (*Vespertina*).
2. With two wings (*Diptera*).
3. With elonged jaws and two wings, or none (*Homaloptera*).
4. With wings not perceptible—fleas (*Aphaniptera*).
5. Without wings (*Aptera*).
6. With two wings and overlapping wing-cases (*Hemiptera*).
a, Land insects (*Terrestria*).
b, Water insects (*Aquatica*).
7. With two wings and wing-cases not overlapping each other (*Homoptera*).

THE QUINARY SYSTEM.

MR. W. S. MACLEAY, the author of this system, proposes to arrange insects in circular groups of fives, so as to place those which have the nearest resemblance, or (as he terms it) *affinity*, contiguous to one another in their several circles. We shall here give from the Horæ Entomologicæ his arrangement of Clairville's *Mandibulata*, with translations, &c. of his terms.

MacLeay's Classification.



Insects have also been divided according to the condition of their food; but the arrangements on this principle have not, as far as we know, been perfected.

I. INSECTS FEEDING ON LIVING SUBSTANCES (*Thalerophaga*).

1. Feeding on living flesh (*Carnivora*).
   a, Feeding on aphides (*Aphidivora*).
2. Feeding on growing vegetables (*Phytophaga*).
   a, Feeding on grain and seeds (*Granivora*).
   b, Feeding on fungi (*Fungivora*).

II. INSECTS FEEDING ON DEAD SUBSTANCES (*Saprophaga*).

1. Feeding on dead wood (*Lignivora*).
2. Feeding on dung (*Coprophaga*).
3. Feeding on dead animals (*Necrophaga*).

ILLUSTRATIONS OF VOL. II.

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